CANTERBURY REGIONAL ENERGY STRATEGY PROJECT

Work Stream 01: Grid Connected Energy System

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Approved by:

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Glossary

CRESG	Canterbury Regional Energy Strategy Group / Canterbury Regional Energy Forum
CRESG Members	Canterbury Employers' Chamber of Commerce, Environment Canterbury, Meridian Energy, Orion Networks and Transpower, and invited representatives from the Canterbury District Health Board and the Christchurch City Council
Common Language	A summary and comparison of key specification, planning and performance criteria used in the electricity sector. Intended ultimately to form a standardised and harmonised set of criteria to facilitate regional collaboration and cooperation in energy planning and investment
EC	Electricity Commission
Regional Energy Compendium	An overview of both grid and non-grid connected energy infrastructure, assets and resources within the Canterbury Region
EEA Guidelines	Power Industry Guidelines developed by the Electricity Engineers Association of New Zealand
N Security	Is a network architecture without any redundancy. An outage to customers will occur in the event of a single failure or failure (N) in the network.
N-1 Security	Is a network architecture that includes redundancy for a single fault or failure event
N-2 Security	Is a network architecture that includes redundancy for two separate fault or failure events
N-g-1	Is a network architecture that includes redundancy for a single separate fault or failure event, including generation failure
Interrupted n-1 Security	Is similar to 'N-1 Security' but following a single fault the power supply is interrupted for a short period of time whilst switching of the network takes place. The advantage of this type of security over the 'N security' case is that power can be restored in switching time as opposed to fault repair time. For an 11kV cable network, this is typically a 6-8 hour time saving for each fault.
Interrupted n-2 Security	Is similar to 'N-2 Security' but following a double fault the power supply is interrupted for a short period of time whilst switching of the network takes place. The advantage of this type of security over the 'N Security' and 'N-1 Security' cases is that power can be restored in switching time as opposed to fault repair time. For a 66kV cable fault, this is typically a 5 day time saving.
Grid Upgrade Plan (GUP)	The grid upgrade plan is a plan for grid expansions, replacements and upgrades, produced by Transpower at the request of the Electricity Commission
Grid Investment Test (GIT)	Is an economic test undertaken when comparing the costs and benefits of different network solutions. Its general form is prescribed by the EC.
Grid Reliability Standard (GRS)	Is used to provide a basis, in conjunction with the Grid Investment Test (GIT), for planning and development of the national transmission grid.
Optimised Deprival Valuation (ODV)	Is the regulated value of a network and provides a value basis for calculating prices within that network

Outage	An ‘outage’ to customer connections is considered to have occurred if supply is disconnected for any duration. That is, any noticeable loss of power to a customer connection constitutes an ‘outage’. *This differs from the regulatory definition where the power must be off for more than one minute to constitute an ‘outage’.* This change in definition allows the true cost of short outages to customers to be captured in the analysis.
Probabilistic Standard	Probabilistic standards are based on the probability of failure of specific assets against the value of lost load to customers at that location. However, they do not deliver a known outcome for a particular event.
Deterministic Standard	Deterministic standards are based on the average level of security required for typical geographical locations, load group sizes and customer types. For a given fault, a deterministic standard always delivers a known outcome.
Switching Time	The time it takes power to be restored via network open point changes in the event of a fault.
Total Cost of Outage (TCOO)	The total annual cost of outages to customers when implementing specific network architectures.
Value of Lost Load (VoLL)	This is the average value that an average consumer places on un-served load or unsupplied energy.
Value of Interruption (VOI)	This is the value that an average consumer places on an interruption to supply. Unlike VOLL, VOI is the consumer cost of experiencing the first minute of an outage.
Value of Customer Reliability (VCR)	This is term used by VENCORP (Victoria authority in Australia) to describe the equivalent of VOLL + VOI in this report.
Security of Supply	The inherent ability of a network to meet the customer demand for energy delivery without interruption.Is a function of system configu-ration and its inherent ability to continue operation under contin-gencies.
Reliability of Supply	**(also known as Adequacy)** The actual performance of the network in terms of the amount of interruption actually experienced by the customer [EEA definition]
SAIDI	***“System Average Interruption Duration Index”*** - measures the average number of minutes per annum that a consumer is without electricity.
SAIFI	***“System Average Interruption Frequency Index”*** - measures the average number of times per annum that a consumer is without electricity.
Constraint	A local limitation in the transmission capacity of the grid required to maintain grid security or power quality.

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EXECUTIVE SUMMARY

Energy is both a national and a regional issue, and ensuring a secure and reliable energy supply is an inherent component of meeting the energy needs of future generations.

Yet, when one looks at the New Zealand energy system and reflects upon the apparent policy failure that have characterise national action over the last two decades on energy security and future supply, then one can not but conclude that a different approach is required. Further reflection will identify that the energy system, itself is characterised by the *interdependencies* that govern supply and demand, and the *co-dependencies* that determine system resilience and reliability.

Together these dependencies and complexities form the settings within which the risk and vulnerabilities inherent in the supply and delivery of energy services manifest themselves. It is a complex system, made more complex by consumer expectations of a reliable and affordable supply.

A competitive energy supply is a prerequisite to continued economic growth and improvements to social well-being. Assurance of supply is therefore about managing our energy vulnerabilities and making informed decisions for the future. It is ultimately about sharing in the responsibility for creating the balance between multiple and at times competing goals. Failure of the industry to rise to this challenge has instead lead to the current situation where consumers are expressing their strong dissatisfaction with existing regimes and are asking how, as a country, we can do better in meeting future energy needs?

This project is intended to pick up that challenge. It has set out to take a different look at the energy equation and by so doing, to achieve for the people of Canterbury a secure supply of reliable and affordable energy.

In particular, the Canterbury Regional Energy Strategy Project is intended to improve energy delivery to the region through:

- an assessment of Supply Reliability;
- an assessment of System Resilience;
- offering a framework for regional collaboration; and
- identifying and addressing infrastructure assurance priorities.

In essence the project is about providing improved choices, the ability to make informed decisions and sharing in the responsibility for risk mitigation with regards the total energy system and security of supply.

The Study aims to articulate the critical issue facing the region, and to explore the trade-offs that will be required to reach a balanced perspective on the current situation. It is hoped that by so doing, there will be community agreement as to the broad-based priorities for improving the resilience of the system, as well as action to catalyse investment in the underpinning infrastructure required by the region.

Key Findings

1. The Canterbury region is very heavily reliant on Transmission to supply energy to the region as it has limited regional generation and is 'selectively endowed' with other non-electric energy resources.
2. The study team noted that the various stakeholders did not consistently apply the projections of future demand. *This leaves open the question of how best to get agreement on future demand projections?*
3. Notable also is the fact that almost all future forecast generation growth is dominated by non-firm renewable energy, an indication that the existing reliance on grid supply is likely to remain and that the timing of future grid upgrade decisions will be critical to addressing future supply risk. *We ask, instead, how the options for security of supply and regional growth requirements are factored into preferred investment plans?*
4. Currently, it appears that the grid in the upper half of the South Island only has n-1 security because of operational constraints.

This raises the question as to whether the grid planning criteria is too narrow and doesn't accommodate the effects of proposed upgrades on a wider regional/market area.

5. At the sub-transmission or distribution level, maintaining n-1 security may not be the best solution for all market participants as the cost involved in maintaining this security level could potentially outweigh the economic value of the un-served load. *This forms the basis of the ongoing discussion regarding core vs non-core grid, and rural vs. urban security of supply requirements.*

6. Distributed generation is unlikely to be a satisfactory response both at transmission and sub-transmission levels for maintaining n-1 security levels under all operational conditions.

7. Potentially, local / distributed generation exposes the Upper South Island, increasing nodal risk and retailer exposures by deferring upgrades to the transmission grid. The question remains as to whether there are more appropriate strategies to manage the risks to the network arising from large interregional flows.

8. Different investment plans result in different distributions of the benefits of the investment. There may be a case for exploring the "weakest link" in relation to regional security standards. *We therefore ask how does one establish an appropriate trade-off between regional benefits versus a national perspective in terms of a regions net contribution to the entire system?*

9. Associated with the n-1 security of the grid is the load profile of the Canterbury region. Large amounts of peak shifting occur to flatten out the demand over normal peaking times. *The question thus arises as to what extent should the grid rely on peak shifting in order to provide n-1 security?*

10. Our understanding of the age distribution of current assets and the lack of power factor correction with the networks suggests an inefficient sub transmission sector characterise by high standing losses. *However, we accept that this is a proposition that remains to be tested and we intend to do so in Stage 2.*

11. We suggest that the Grid Investment Test (GIT) does not satisfactorily account for a number of important issues, in particular the interdependency of transmission and generation and that the National Grid should be considered a "system of systems".

12. We argue that the inability of the GIT to take this into account can conceivably result in sub-optimal investments being made, which may be at odds with other policy initiatives such as the Climate Change Strategy or National Energy Policy. The extent of this misalignment is something we intend to assess in Stage 2.

13. The objective function of economic efficiency desired by the GIT does not adequately provide for regional economic development priorities and community needs.

Creating an appropriate channel that will allow regional priorities and community desires to become an input into the national decision making framework is a fundamental premise of this study.

14. The economic efficiency that drives the incremental investment process results in economies of scale being lost. Anecdotal evidence suggest that investment signals are not present in the market early enough to be able to justify large scale investment. We intend to investigate this further in Stage 2.

15. The decreasing affordability of energy as a result of the factors above is evident in the increasing proportion of the community becoming "energy poor", defined as the situation where energy costs exceed 10% of a person's wage.

16. Reserve margins in the system are getting smaller due to the delays in generation investment. This loss may be further compounded by unanticipated events outside the control of the GIT process, e.g. delays in the RMA consent process.

17. This shrinking of the margin affects the ability of the system to cope with unforeseen events. A reliable system come about form the combination of security and adequacy. It would seem that what is considered adequate for Canterbury remains open to debate. This is an area for further investigation as part of Stage 2.

The Study Team acknowledges the need to work within the existing industry and regulatory processes but is instead asking whether it is possible to introduce a new planning paradigm that will facilitate the prioritisation of regional and community requirements in the national decision making framework.

This paradigm will be a combination of a Regional Statement of Opportunities, supported by a Common Language and Collaboration Protocol that is aligned with both ECan's Regional Energy Strategy and the proposed National Energy Policy.

1 INTRODUCTION

The Canterbury region is one of the fastest growing regions in the country. To propel this development, energy from various sources and types is utilised to power industry and agriculture, and support business, development and lifestyle. Energy survey information illustrates the overall trend of increasing (as the trend is nationally), rather than stabilising or decreasing energy use, and our dependence on oil products. Our ever-increasing dependence on energy for both 'stationary' and 'mobility' purposes coincides at a time when the region [2] faces significant future uncertainty in the area of availability and prices of some energy sources.

Energy has become both a national and a local issue due to factors such as electricity industry reforms of the last decade, a growing community reliance on high quality energy services and, increasingly, climate change and other environmental issues. This shift in focus is supported by the growing policy emphasis towards sustainable development and associated actions; of which a vital component is addressing energy security and supply and demand issues within the framework of creating for the country and its regions, a sustainable energy system.

Increasingly, as evidenced by the Canterbury regional energy seminars held in late 2005, individuals and communities are looking for solutions and to influence policy so as to mandate better outcomes, as they perceive the issues. These issues will need to be dealt with in the context of the Canterbury energy system - which has unique attributes in terms of: energy use patterns, location issues, user issues (e.g. service standards) and network issues.

The 'cross-roads' issues we face are now being reflected in regional communities asking for regional solutions and a seeking an appropriate balance between developing or maintaining macro energy infrastructure versus provision of smaller distributed and 'micro' solutions. There is now more evidence available both nationally (CAE, 2003 [3]) and internationally (e.g. Hoffman and High-Pippert, 2005 4]; DTI, 2006 [5]) to suggest that 'community energy', based on a mix of distributed technologies offers a serious alternative or supplement to our centralised power system.

Notwithstanding the impact of the NZ Energy Strategy, a number of key programmes and legislation attempt to deal with enabling an effective and sustainable energy system including: the NEECS; the RMA; and (indirectly) the LGA [6].

The RMA has greatest significance currently to councils. The 2004 RMA amendments require a taking into account the '*benefits to be derived from the use and development from renewable energy*'. The region's Regional Policy Statement (RPS) is the key means by which the purpose of the RMA can be achieved with a regional energy strategy (RES) [7] being a core method to achieve those RPS requirements.

Further amendments to the RMA in 2005 now require regional and district councils to give effect to the RPS and for regional and district councils to agree upon the consultation process for a review (process is now underway). The relationship between regional and territorial authorities in relation to energy issues has been of little importance until now but this is set to change. The territorial councils are now able to play a stronger role by ensuring that district plans reflect the renewable energy objectives of the RPS (such as making provision for various scale energy generation facilities); and considerable scope exists for flexibility for applying more liberal consent terms (thresholds and duration) when applied to renewable resources.

Energy considerations (in the form of appropriate space heating technology) are also a feature of ECan's Clean Air Policy (CAP). The National Environmental Standards for Air Quality (NES) require improvement in air quality between now and 2013 to avoid impact on the region's economy (driven in large part by growing demand for electricity services). ECan's Proposed Air Plan [52] and Clean Heat

Project (CHP) are the key means of meeting the NES. ECan's CHP is designed to replace the use of old style (pre-1992) fuel burners and open fires; and substitute their use with 'clean' (air emission) alternatives [53].

This Report is intended to present a high level overview of the Grid-Connected infrastructure in the Canterbury region as seen from various perspectives – i.e. stakeholder, security of supply, affordability etc. In doing so, the Study Team has attempted to identify commonalities as well as misalignments in specification, delivery and performance criteria, which arguably are contributing to increasing vulnerabilities in the supply of energy to the region.

2 STUDY OUTLINE

The Canterbury Regional Energy Strategy Project (CRESP), sponsored by the Canterbury Regional Energy Forum, is aimed at securing the future of energy supply in the Canterbury Region through the development of a new paradigm that will facilitate cooperation among regional stakeholders, provide regional input into regulatory decision making processes, and secure industry agreement and collaboration to achieve a desired set of outcomes and options that would ensure the security of energy supply to the Canterbury region for the future.

Central to the development of such a paradigm would be effective communication mechanisms between regional stakeholders, so that information related to risks and vulnerabilities of the regional energy system can be communicated to all stakeholders in such a way that they can easily understand what is important and can use the information to make informed decisions, in the face of conflicting and competing public goals, corporate objectives and multiple responsibilities.

Ultimately, this project is intended to contribute towards an integrated Regional Statement of Opportunities that will:

- Articulate the critical energy issues for the Canterbury Region;
- Characterise the risks and vulnerabilities inherent in energy supply to the region
- Critically investigate all viable options to achieve the desired energy balance;
- Align the investment plans and decision making frameworks of the regional stakeholders; and,
- Achieve regional agreement on the effects of trade-offs to reach a balanced perspective that takes account of security, risk, economic opportunity and consumer preferences.

This will provide broad based priorities for improving resilience and investment in the underpinning energy infrastructure to the betterment of all in the region.

Approach

In order to ensure a robust framework for analysis, the Regional Statement of Opportunities will be based upon a sound foundation of data gathering, consultation, expert knowledge and decision support tools which will allow the prioritising of future effort and benchmark comparisons with the other regions. This project is intended to be a leading project that will become a model for other regions to follow.

In order to provide this sound foundation it is proposed that the project is separated into three Stages.

- Stage 1 will be concerned with the development of a consistent framework and methodology, both for the project itself, and for ongoing future regional policy development.
- Stage 2 will be focused on the development of an effective language to describe infrastructure resilience in terms that are widely understood by stakeholders and convey meaningful information to all industry participants.
- Stage 3 will focus on the community consolation and communication plans that are essential for realising potential opportunities whilst managing community expectations for an affordable and reliable energy supply.

Specifically, the scope for Stage 1 was to:

- To characterise the energy system in the Canterbury region, in particular, reviewing system characteristics, vulnerabilities, potential investment opportunities and other relevant issues;
- To investigate the broad parameters and protocols for a framework that would allow major regional stakeholders to collaboratively address critical issues to ensure the future security of energy supply in the region;
- To review, align and standardise key concepts, definitions and terminology used by key regional stakeholder to ensure more effective communication and collaboration.

Expected Outcomes

The project is intended ultimately to provide a road map for determining future energy options for Canterbury, and a framework for regulatory decision-making. This road map will identify the critical energy assets for the region, its resources and future utilisation options, and characterise the risks and vulnerabilities of future choices for the region.

Deliverables

The deliverables for this work stream, WS01, were as follows:

a. A 'Snapshot' of the Grid Connected component of the Canterbury Energy System (resources, assets, vulnerabilities, etc)

b. A Template for a Regional Collaboration Framework that will allow major regional stakeholders to engage with each other to address energy issues in Canterbury;

c. A Common Language Vocabulary or Lexicon to support the Collaboration Framework

And also contribute towards:

d. A Template for an Updateable Regional Energy Compendium, that will contribute towards Environment Canterbury's Regional Energy Plan and Regional Energy Policy

e. A Programme of Action for Stage 2, that is expected to contribute towards the development of a Regional Energy Road Map and Regional Energy Investment Plan in Stage 3.

The principle driving this process is recognising that no one solution is correct and that community awareness and participation will lead to improved choices.

About CAENZ

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3 REGIONAL CHARACTERISTICS

Economic Profile

The Canterbury economy accounted for 14.6% of total economic activity in New Zealand in the year to March 2004.

Its regional GDP in the same year totalled $19.9 billion, with a per capita nominal GDP of $35,650 in the year to March 2003, compared to a national figure of $32,100. Canterbury's per capita real GDP grew at an average of 3.7% between March 1998 and 2003, well above the New Zealand growth rate of 2.3%.

Canterbury's unemployment rate averaged 4.1% over the year to June 2004, compared to a national rate of 4.3%. The region's labour force participation rate is the highest in New Zealand, suggesting that the vast majority of able and willing workers are actively employed. This is reflected in the relatively high GDP per capita in the region. It also indicates that any additional economic growth will have to stem from population growth or labour and capital productivity gains.

Labour productivity (real GDP per employee) in Canterbury grew at an average of 0.8% between 2000 and 2004. Nationwide, labour productivity growth averaged 0.9% per year over this period.

Canterbury spends an above-average amount on economic development relative to its GDP ($1,300 per $million of GDP), compared to New Zealand as a whole ($1,100 per $million of GDP). Despite this expenditure, the region's enterprise creation and destruction rates are not vastly different to the national averages.

Economic Growth

Canterbury's economic growth between March 2000 and 2004 averaged 4.8%, compared to a national average of 3.5% for the same period, making Canterbury the second fastest growing region of those covered by NZIER's regional economic dataset.

The steady growth in the Canterbury economy of the past few years is, however, expected to slow in the near term. Current forecasts indicate that the South Island economy is cooling, with the annual rate of economic growth forecast to fall from 3.8% to 3.2%. Although this cooling trend is expected to continue for a few years, economic growth is still predicted, but at a slower rate than the past few years. In the Canterbury region, there has most recently been a decline in economic growth, with growth of 2.2% (quarter for quarter) in quarter 1 of this year, giving way to a 0.4% drop in quarter 2. This has been primarily attributed to the Canterbury economy's exposure to manufacturing and tourism, which are particularly vulnerable to recent high exchange rates and increased oil costs.

Population Growth

The 1996 and 2001 Census data suggests a projected Canterbury population of 558,600 in 2016 and 584,400 by 2026 from an estimated base population of 526,300 in 2005 [Regional Gravel Management Report 2006]. The following table provides the projected population growth rates for the Canterbury region.

	Change		
Period	Number	Percentage Increase	Ave. Annual Rate of Change
1996-2005	45,900	9.5%	1.0%
2005-2016	32,300	6.0%	0.6%
2016-2026	25,800	4.6%	0.5%

Table 1: Projected Canterbury Population Change 1996-2006 [Regional Gravel Management Report 2006; p34]

Population growth generally goes hand in hand with economic growth, and concentrations of population generate on-going demand for electricity and the requisite investment in transmission and distribution infrastructure.

When population growth is considered on a more magnified scale, such as on a district-by-district basis, it can provide an indication of the areas where growth, and therefore infrastructure investment, is most likely to occur. The following map represents the Canterbury Region using colour coding to show a percentage change in the population across the region. The data used for the map was sourced from Statistics New Zealand, and estimates population change for each district out until 2016.

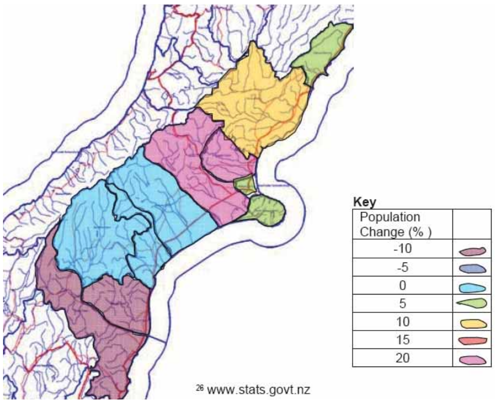

Fig 1: Canterbury District Population Projections to 2016 [Regional Gravel Management Report 2006; p40]

This map indicates that population growth for the South Canterbury districts of Waitaki and Waimate is expected to decrease by more than 5% over the period to 2016. Population in the Mackenzie, Timaru and Ashburton Districts are predicted to stagnate, while Banks Peninsula, Christchurch and Kaikoura districts will have an approximate 5% increase in population. The areas of greatest growth will be the Hurunui District with a 10% growth rate and Selwyn and Waimakariri Districts, where a 20% growth rate is predicted.

Industry Profile

The following table compares Canterbury's regional economic structure against the broader New Zealand economy. Plots to the right side of the dotted line (e.g. trade and tourism) indicate that the specified industry accounts for a larger proportion of the Canterbury GDP than it does at a national level; *i.e. the industry is more 'important' to the Canterbury region than to the New Zealand economy as a whole.*

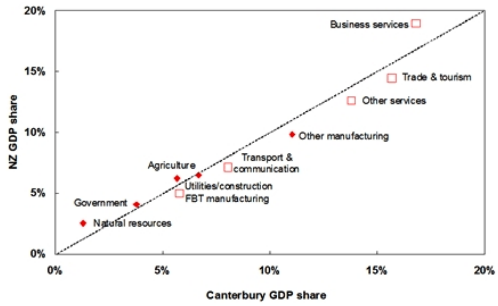

Fig 2: Canterbury's Industrial Profile [NZ's Regional Economic Performance - Regional Highlights 2006. NZIER for MED: p17]

The 'square' scatter plots are industries that are fast-growing at a national level, while the 'black diamond' scatter plots are industries that are slow-growing at a national level.

This diagram suggests that relative to the national economy, Canterbury is:

- Highly reliant on various manufacturing sectors;
- Relatively highly dependent on faster-growing sectors (e.g. food, beverage and tobacco manufacturing, trade, tourism and other services);
- Under represented in the business services, agriculture, natural resources and government sectors, (which apart from business services) are all relatively slow-growing sectors at the national level.

Fast-growing regions tend to have a high proportion of their regional economies focused on fast-growing sectors, which may explain in part why the Canterbury economy has grown rapidly in recent years.

4 NEW ZEALAND ELECTRICITY SYSTEM

New Zealand Electricity System

The electricity system in New Zealand is characterised by a long skinny high voltage transmission system that runs through the centre of the country.

The system transmission system is connected between the North and South Island by a 1200MW HVDC submarine cable link across the Cook Strait. Due to the geographical isolation of the country, there are no interconnections with other power systems.

Annual generation is approximately 36,000 GWh and is dominated by hydro- power, although this has decreased from approximately 75% in the 1990's to around 60% of total generation today. Other types of generation include gas (30%), coal (10%), geothermal (5%), wind and various small scale biomass and solar.

Transmission of generation is very important as the geographical generation centre is at Benmore in the lower South Island but the geographical demand centre is in Hamilton. This discrepancy requires electricity to be transmitted long distances across the system.

Markets and Market Participants

The electricity industry in New Zealand has four main categories of market participation. These are retail, distribution, transmission and generation.

The participants that compete in the market are the retailers and generation. Transmission and distribution are considered to be natural monopolies and so operate their own networks with the regulations of electricity market. The wholesale market is the market in which generators compete to sell their electricity-to-electricity retailers and other purchasers such as major commercial and large industrial users. Every half hour each retailer submits and demand bid and each generator submits an offer of generation. The System Operator takes these bids and while considering security implications and operational parameters, dispatches the lowest cost generation for that half hour. The retail market is a market where electricity retailers compete to sell the electricity they have purchased on the wholesale market, to consumers including small-scale industrial and commercial users and domestic consumers. Retailers can also purchase electricity directly from embedded generators (smaller generators connected directly to distribution networks such as biomass, landfill, and wind turbine generation).

There are various views on how the market achieves the overall objectives set out in the Electricity Act and Governance documents but these issues are beyond the scope of this project. There is however a close linkage between market price and investor confidence and some of these risk issues will be discussed in subsequent sections of the report.

The following diagram provides an illustration of the New Zealand Electricity System in some aspects. It is included in this report for illustrative purposes, but reinforces the complexity of the institutional, market and regulatory arrangements, which ultimately govern industry investments. Obtaining an optimal solution within such a framework for the physical delivery of electricity at least cost is thus fraught with difficulty.

Electricity Sector Governance

The following extract from the Draft Government Policy Statement on Electricity Governance - August 2006 - provides the high-level objectives for the industry:

"The Government Policy Statement sets out the objectives and outcomes the Government wants the Commission to give effect to. It is made pursuant to s172ZK of the Electricity Act 1992 as amended by the Electricity Amendment Act 2004[1]."

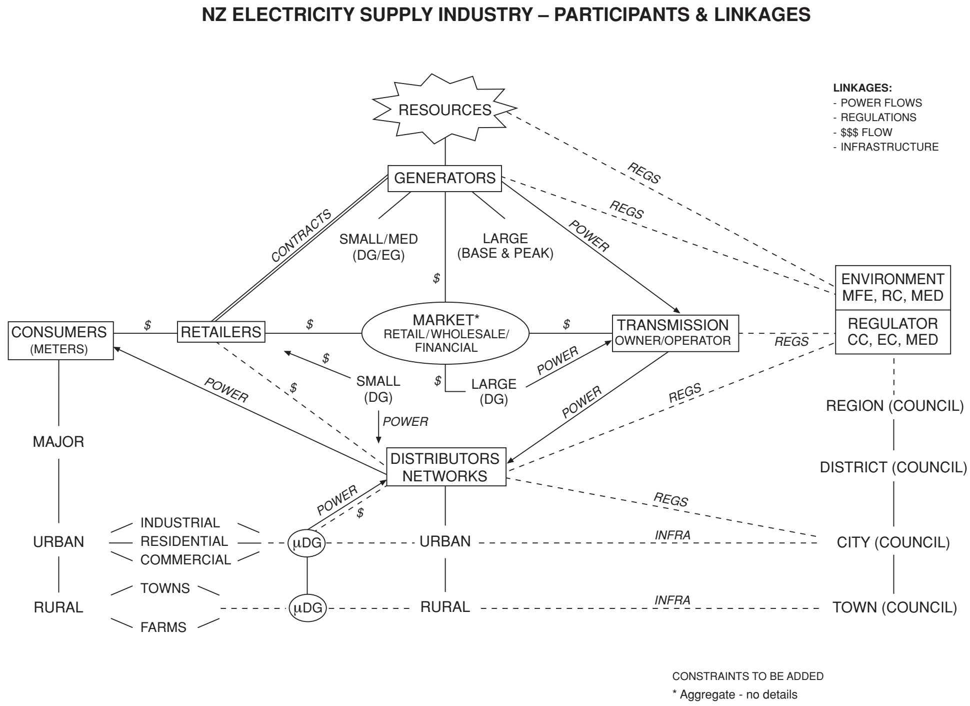

Figure 3: New Zealand Electricity Supply System – Participants & Linkages [Source: Geoff Cardwell]

This August 2006 version of the Government Policy Statement is a limited revision of the October 2004 Government Policy Statement. To aid clarity, the original October 2004 paragraph numbers have been retained.

Security of Supply Background

35. A key priority of the Government is to improve security of electricity supply. ….. In the Government's view, security of supply is vital to achieving its objective of sustainable economic development.

36. Key components of security of supply are that:

- *Sufficient generation capacity is built or energy efficiency improvements made to meet ongoing demand growth*
- *Hydro and thermal generating capacity and fuels are appropriately managed, to deal with the risks of extended dry hydro periods better than we have in the past*
- *The system has sufficient reserve energy (plant and fuel, or contracted demand response) to cope with extreme dry sequences or other unexpected supply disruptions*
- *The national grid and distribution lines meet specified reliability objectives. (Transmission and distribution issues are covered in separate sections).*

Security of Supply Policy

41 The Electricity Commission should develop, consult on and publish a security of supply policy. The security of supply policy should specify the steps that the Commission will take at various stages during a contingent event such as an extended dry sequence. It should also include its procurement policies for reserve energy. The overriding objective is to give as much certainty as possible to the market.

42 The Commission should develop and publish an operational security of supply standard, possibly expressed as a loss of load expectation.

The EC is seen as the regulator in the industry and oversees the markets by ensuring adherence to market rules and making recommendations for new rules. The EC is also responsible for ensuring that the electricity industry and markets operate efficiently on a day-to-day and longer-term basis. To achieve this it has contractual service provider agreements with a number of organisations for managing the operations. The EC also oversees industry governance, which includes consideration of any alleged rule breaches by industry participants and applications for exemptions to the rules. All market participants must operate within the market rules, with each type of market participant operating under different requirements and constraints.

5 SYSTEM CHARACTERISTICS

Generation

The Canterbury region (excluding South Canterbury), as defined in Transpower's Annual Planning Report, encompasses the area bordered by and including Kaikoura in the north, to Springston and Hororata in the south, and west to Hororata and Coleridge power station. The region's main generation is the Coleridge Power Station. This is a 45MW capacity hydro generator that enters the core grid at the Islington GXP.

The South Canterbury region covers the area bordered by and including Ashburton in the north and Livingstone and Oamaru in the south. This region contributes a major portion of the generation in the South Island, feeding the 220 kV network from the Tekapo B, Ohau and Waitaki Valley generation stations. The complete list of generation plant is as follows:

- Tekapo A
- TekapoB
- Ohau A
- Ohau B
- Ohau C
- Twizel
- Aviemore
- Benmore
- Waitaki

Embedded generation plant contributes a very small amount of generation to the region; approximately 3GWh in the Orion network and a 7.5MW hydro station embedded in South Canterbury at Opuha, in addition to Montalto (1.6 MW) and Highbank (26 MW) in the Electricity Ashburton Network.

Transmission and Grid Connections

Canterbury

Canterbury's transmission network comprises 220 kV and 66 kV transmission circuits with interconnecting transformers located at Bromley and Islington. The major transmission circuits feeding the central Canterbury (Christchurch and surrounds) are the Tekapo 220kV, Livingston 220kV and Twizel 220kV (2 circuits). These transmission circuits connect at either the Islington or Bromley substations. Supplying areas north of the Canterbury region are 3, 220kV circuits to Kikiwa. These lines originate at the Islington substation.

There are a number of GXP's supplying the various sub-transmission and distribution networks within Canterbury. The largest GXP's are at Islington and Bromley as these substations are primarily responsible for supplying the large urban load in Christchurch. Both these GXP's supply power from the 220kV grid while the rest of the region is supplied from the 66 kV, including the:

- North Canterbury GXPs;
- Addington and Papanui GXPs; and
- Springston and Hororata GXPs.

Reactive support is provided at Christchurch from synchronous condensers, static var compensators and capacitor banks at Islington and Bromley

South Canterbury

The South Canterbury region is supplied by 220 kV and 110 kV transmission circuits with interconnecting transformers at Timaru and Waitaki. The 110 kV network is normally operated split at Studholme creating two radial feeds:

- Timaru 220/110 kV interconnecting transformer banks supplying Albury, Tekapo A and Temuka; and
- Waitaki 220/110 kV interconnecting transformer banks supplying Studholme and Oamaru.

This region contributes a major portion of the generation in the South Island, feeding the 220 kV network from the Tekapo B, Ohau and Waitaki Valley generation stations.

North Canterbury

The North Canterbury area is considered by

Transpower to be within the Canterbury region itself. This area operates mostly at the subtransmission level, where Transpower owns the 66kV network. The 66kV network is supplied predominantly through the Islington and Bromley substations, along with the GXP's listed below.

- Southbrook 66kV/33kV
- Kaiapoi 66kV/11kV
- Ashley 66kV/11kV
- Waipara 220kV/66kV
- Culverden 220kV/33kV
- Kaikoura 66kV/33kV

Recent Transmission Projects (Canterbury and South Canterbury):

A number of transmission projects have recently been commissioned in early 2006 including:

- A third 220 kV circuit between Islington and Kikiwa;
- 220 kV interconnection at Waipara and Culverden; and
- A new GXP at Black Point.

The following diagrams show the existing transmission network in the Canterbury plus North Canterbury and South Canterbury regions respectively.

Sub-transmission / Distribution Networks

The Canterbury and South Canterbury regions have four main areas of sub-transmission and distribution. Each of these areas is owned and operated by a separate company.

- Network Waitaki encompasses the areas of North Otago and the Hakataramea
- Alpine Energy encompasses the region between the Rangitata and Waitaki rivers and inland to Mount Cook.
- Orion encompasses a large area including Christchurch city, Banks Peninsula, the Port

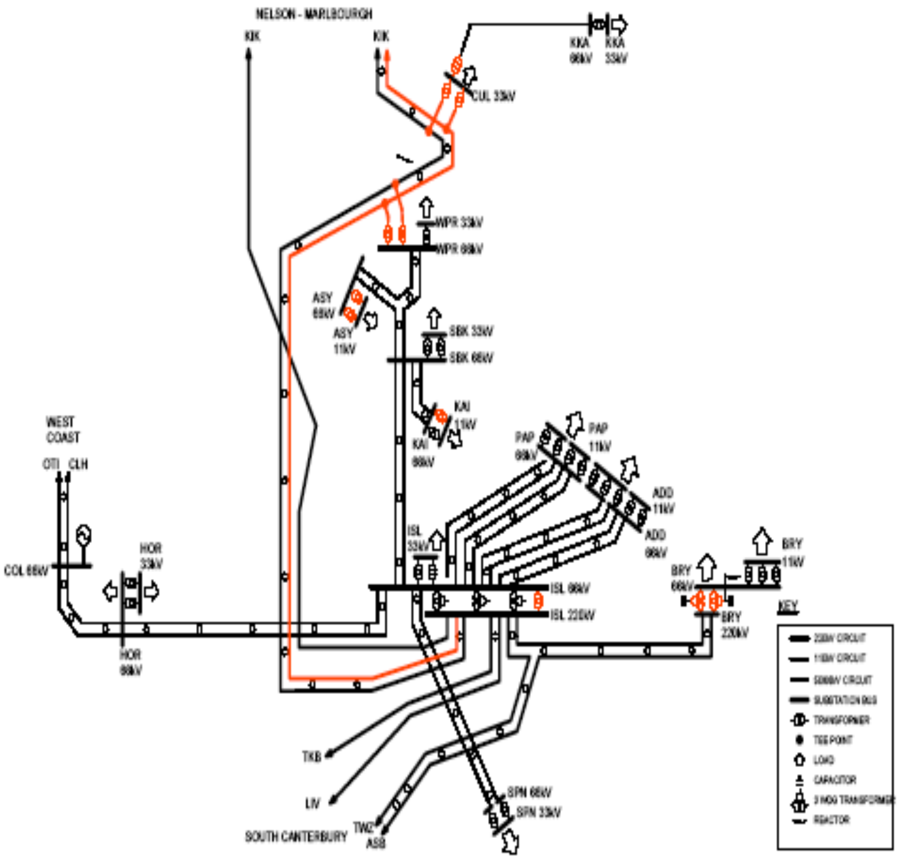

Fig 4: Canterbury Transmission Grid [Source: Transpower APR 2005: 240]

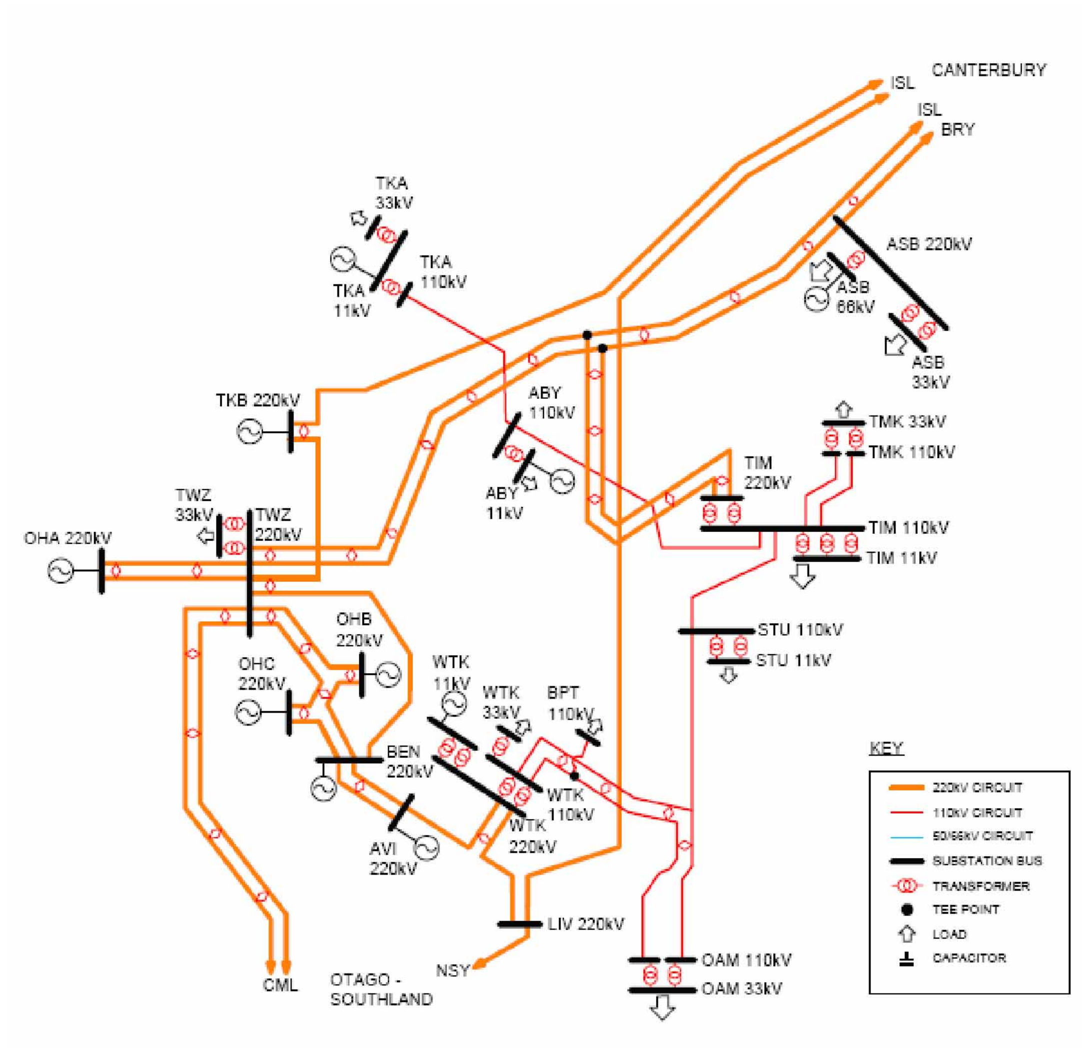

Fig 5: South Canterbury Transmission Grid [Source: Transpower APR 2005:243]

of Lyttelton and the farming communities of the Canterbury plains between the Waimakariri and Rakaia rivers and the high country area inland to the main divide of the Southern Alps

- MainPower operates the network in North Canterbury from north of the Christchurch urban region, inland to the Southern Alps and northward to Kaikoura. The Mainpower network also includes the Wigram area of Christchurch, supplied from the Orion Network rather than a Mainpower substation.

Alpine Energy

The Alpine Energy network is supplied from six GXP's

GXP	*Transformer*	*Capacity*
Timaru	220/110kV to 33/11kV	60MW
Temuka	110kV to 33kV	40MW
Studholme	110kV to 11kV	12 MW
Albury	110kV to 11kV	3MW
Tekapo	110kV to 33/11kV	2.5MW
Twizel	220kV to 33kV	2.5MW

The Network delivers approximately 640GWh of energy and has a system Maximum Demand of 103MW.

Electricity Ashburton

The Electricity Ashburton network is supplied from two GXP's, both sourced from the same Ashburton substation.

GXP	*Transformer*
Ashburton 33kV	220kV to 33kV
Ashburton 66kV	220kV to 66kV

Together these GXP's serve a load of approximately 95MW maximum demand and delivered 386.6 GWh. Recent investment in the network has increased the amount of Subtransmission at the 66kV level and consequently the 33kV load is reducing. Toward 2008 it is predicted that additional capacity will be needed in the Ashburton region. Whether this capacity is provided through additional transformer capacity or a geographically separate substation offering an alternative GXP is yet to be determined.

Network Waitaki

(Please note that this data incorporates the entire Network Waitaki region, half of which is classified as being in the Otago region and half in the South Canterbury region. Further information on the demand split within the network will hopefully be available in the future)

The Network Waitaki region is currently supplied from 3 GXP's.

GXP	*Transformer*	*Capacity*
Oamaru	110kV to 33kV	29 MW
Waitaki	200/110kV to 11/33kV	4.5MW
Twizel	200/33kV*	
Black Point	110kV to 11kV	

**is only used at backup for the Waitaki GXP*

Together these GXP's serve a maximum demand load of about 32MW and 202GWh. When the Black Pt irrigation is commissioned it is expected that another 25GWh will be added to annual consumption via this new GXP. Black Point has only recently been commissioned so load data for this GXP is unavailable.

Orion

The Orion network is connected to the grid at 9 GXP's

GXP	*Transformer*	*GXP Type*
Islington	220/66kV to 33kV	Urban
Bromley	220kV to 66kV	Urban
Papanui	66kV to 11kV	Urban
Addington	66kV to 11kV	Urban
Springston	66kV to 33kV	Rural
Hororata	66kV to 66/33kV	Rural
Castle Hill	66kV to 11kV	Rural
Arthurs Pass	66kV to 11kV	Rural
Coleridge	66kV (generation)	Rural

Urban GXPs

Islington and Bromley are 220kV substations, and they provide connection of major circuits from the southern power stations. Addington and Papanui GXPs are supplied by 66kV lines from the Islington 66kV bus. Apart from the Bromley and Islington 33kV supply, all other GXPs are dependent on the Islington 220/66kV interconnection. A potential new GXP may be investigated at Middleton to relieve a constraint on the Sockburn and Middleton 33kV sub-transmission but this is not yet determined.

Rural GXPs

Orion takes power from the grid five rural GXPs; the two main ones located at Springston and Hororata. Each GXP is supplied via a double 66kV line from the Islington 66kV bus. Hororata supplies Orion at both 66kV and 33kV whilst supply at Springston is via the 33kV bus only. Hororata is also connected to the West Coast via 66kV lines from the Coleridge power station. The remainder of the rural area is fed at 11kV from three small GXPs at Arthurs Pass, Coleridge, and Castle Hill.

Combined, these GXP's serve a maximum demand of 577MW and 3190GWh of power. A number of new district substations are envisaged in both the urban and rural area over the next 10 year but the exact location and configuration of these remains to be determined based on load growth and location.

MainPower

Transpower own and maintain the 66kV subtransmission is this region. MainPower operates a 33kV subtransmission system, a large distribution system comprising both 22kV and 11kV voltages, and a low voltage system.

MainPower's network is connected to the grid at six GXP'S:

GXP	*Transformer*	*Capacity*
Ashley	66kV/11kV	Single phase 2 x 10 mVA
Culverden	220kV	2 x 25 mVA
Kaiapoi	66kV/11kV	20 mVA & single phase 10mVA
Kaikoura	66kV/33kV	10/16 mVA

Southbrook	66kV/33kV	2 x 30/40 mVA
Waipara	66kV/33kV	10/16 MW

During the 2005/2006 financial year the demand in the MainPower network was 460.7 GWh's. MainPower's major customers are the CHHP medium density panel mill at Ashley, the Patience and Nicholson tool manufacturing plant in Kaiapoi, the McAlpines sawmill and Mitre 10 plant at Southbrook, the Belfast timber kilns at Coutts Island, the Kaikoura Dairy factory and several large supermarkets and other commercial businesses scattered over Rangiora, Kaiapoi and Kaikoura. Future load growth may require a new GXP at Rangiora East, particularly to reinforce the system when the Pegasus township is built. This new GXP is currently being consulted on.

Demand Characteristics and Forecasted Growth

Current Demand

The current demand for Canterbury and South Canterbury as given by the AMP's (2005/2006 year) of the regional distribution companies is outlined in the table below. Note that the value for Network Waitaki included here is the whole Network Waitaki network, including the area inside the Otago region. It is hoped that the more accurate South Canterbury only value will be available in the near future.

Company	Maximum Demand (MW)
Network Waitaki	32
Alpine Energy	103
Electricity Ashburton	95
Orion	577
MainPower	79
TOTAL	886

Table 2: Regional Maximum Demand

The types of demand can be considered to be in one of two very broad categories, either urban or rural. Urban loads are mostly comprised of residential, commercial and industrial demand whereas the majority of rural demand is irrigation load.

Network companies are reporting load factors of between approximately 60 and 65%, this being quite high in some areas such as Network Waitaki (which is a predominantly rural load). In rural areas where load growth is predominantly in irrigation, the load factor is expected to decrease over time. This is due to the daily load factor (in summer) being high but the annual load factor of irrigation being low. In networks such as Orion's, the load factor is expected to remain steady, as the effect of irrigation on load factor is offset by commercial and industrial loads that have high annual load factors.

Forecasted Demand

The demand forecast for the Canterbury and South Canterbury regions as set out in the Statement of Opportunities (SOO) produced by the Electricity Commission. The following table shows this forecasted demand.

This forecast raises a number of questions about its derivation and assumptions. By looking at the Canterbury and South Canterbury load as a percentage of the total national load it would seem that the Canterbury region load growth matches that of the rest of the country. This seems an unlikely situation when projected population growth is much higher for much of the North Island and Canterbury has a reducing population. Whether this forecast is accurate to use for Canterbury is up for debate.

Urban Issues

The Canterbury region has the largest urban load with the major driver for demand increase being influenced by ECAN's Clean Air Policy (CAP). This program aims to enable Canterbury to meet the national air quality standard that is to be implemented by 2012. The impact of the CAP is to restrict the use of old style fuel burners and substitute their use with 'clean' alternatives. To date approximately 65% of conversions have been to heat pumps. The continuation of the CAP and the switch to alternative heating options is predicted to increase peak winter demand by 35 MW in the next seven to ten years. This forecast is based on an average of 6MW growth per year. The increase in heat pumps may also lead to increased summer peaks due to an increase in air conditioning load though definitive data for this is not yet available. The urban load growth will particularly affect the capacity requirements at the urban GXP's of Islington, Bromley, Papanui and Addington.

Yr	Canterbury (MW)	South Canterbury (MW)	Total Sth Island (MW)	Total Nth Island (MW)	Total NZ (MW)	Cant + Sth Cant as % of NZ total
2005	744	81	2,094	4,230	6,324	13.0
2006	769	82	2,139	4,364	6,503	13.1
2007	793	84	2,185	4,500	6,685	13.1
2008	818	86	2,231	4,640	6,871	13.2
2009	843	88	2,276	4,779	7,055	13.2
2010	867	89	2,319	4,913	7,232	13.2
2011	890	90	2,360	5,043	7,403	13.2
2012	912	92	2,400	5,172	7,572	13.3
2013	934	93	2,438	5,299	7,737	13.3
2014	956	94	2,476	5,423	7,899	13.3
2015	977	95	2,513	5,550	8,063	13.3
2016	998	96	2,550	5,675	8,225	13.3
2017	1,020	97	2,585	5,800	8,385	13.3
2018	1,040	98	2,620	5,921	8,541	13.3
2019	1,060	99	2,654	6,042	8,696	13.3
2020	1,080	100	2,686	6,161	8,847	13.3
2021	1,100	101	2,718	6,279	8,997	13.3
2022	1,120	101	2,748	6,395	9,143	13.4
2023	1,138	102	2,778	6,510	9,288	13.4
2024	1,157	102	2,807	6,623	9,430	13.4
2025	1,176	103	2,835	6,734	9,569	13.4

Table 3: Regional Demand Forecast 2005-2026
NOTE: *SI regional Peak Demand Projections (including high & low estimates based on 90% confidence limits) may be found in Table 27 of the SOO [EC SOO 2005:127-128].*

The urban load duration curve is very flat, in that for most of the year the load deviates very little from its median value. The following diagram taken from Orion's AMP 2006 shows the historical changes on the load duration curve where it can be seen that the maximum demand on the system only occurs for a small number of half hours per year. The historical trend shows that the demand peaks are occurring less frequently, resulting in flatter load profile.

Rural Issues

The largest issue in the rural category is the increase in irrigation load. In the last five to ten years this growth has been very steep although forecasts looking forward indicate this growth to slow. The slowing of growth is due to a number of factors including:

- ECAN's restrictions on ground water allocation
- Land use in some areas is approaching full irrigation potential
- Interruptible load arrangements to cover short term faults
- Requirements of the central plains irrigation scheme.

Forecasting peak load growth due to irrigation is quite difficult due to the use of irrigation being very strongly correlated with weather conditions. The following graph shows the rural demand growth trend and its volatility, mostly due to vagaries in the weather.

Regional Demand Growth Overview

Most networks within the Canterbury and South Canterbury region are seeing annual energy (GWh) growth rates between 2 and 3% and peak demand growth rates of between 1% and 2%. Orion does a lot of work on peak shifting its load, resulting in its peak demand growth rate being at the lower end (1.3% averaged over 20 years)

These growth rates are expected to continue into the foreseeable future. Comparing current

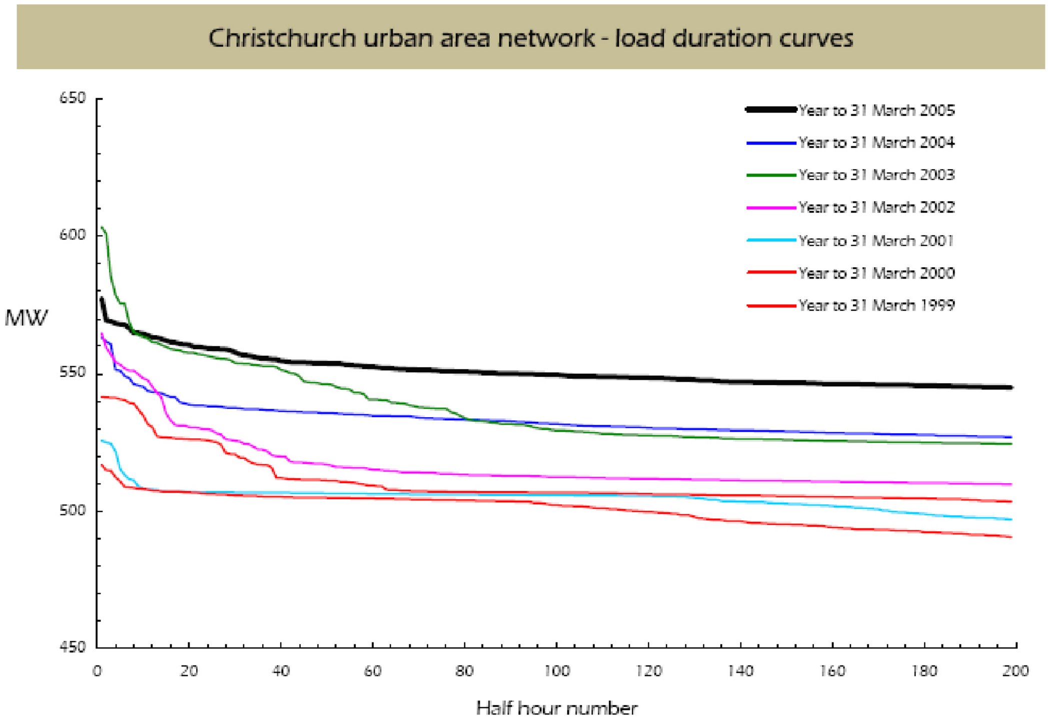

Fig 6: Christchurch Urban Network Load Duration Curve [Orion AMP 2006:17]

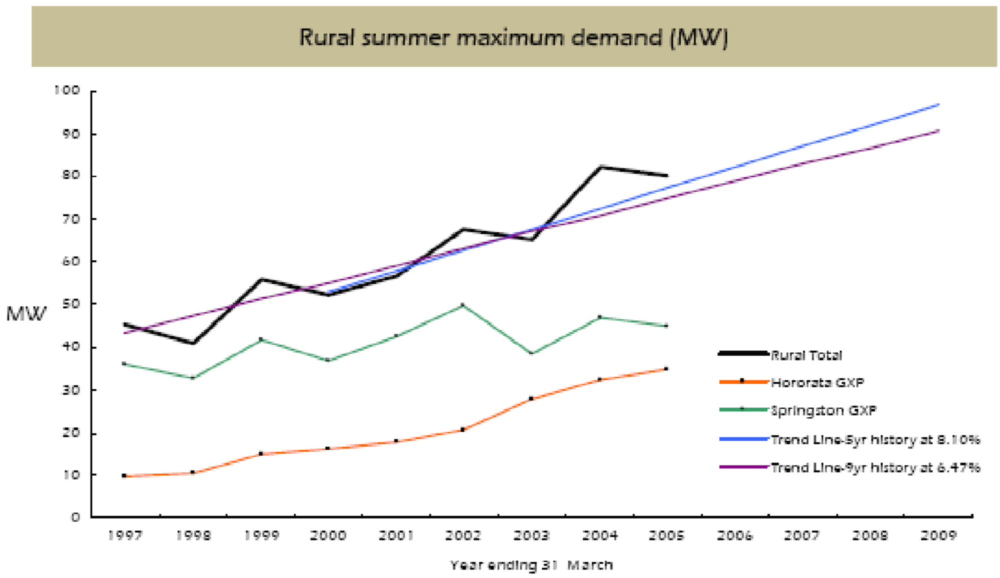

Fig 7: Rural Summer Maximum Demand Trends [Orion AMP 2006:55]

demand with the demand forecast from the Electricity Commission shows that demand is currently tracking the medium demand growth forecast of 2% quite well.

Issues

Maximum peak demand is a hard quantity to predict as it is very dependant on the weather, which in the Canterbury/South Canterbury region can be quite volatile. This volatility is present in both summer, from irrigation (a dry year results in large irrigation load) and in winter (from heating). If the system is running very close to its limit then unexpected cold weather can result in capacity constraints that were not planned for.

Many of the urban GXP's in Orion's network are forecast to run into firm capacity[1] constraints

[1] Firm Capacity is the capacity of a site should one item of equipment fail.

within the next 5 to 10 years. Islington and Bromley are the worst affected, with potential problems also surfacing at Addington, Springston and Hororata. Some projects are already planned to relieve or partially relieve some of these constraints.

Demand growth in Canterbury and north in Nelson/Marlborough is putting significant strain on the transmission system running from the southern generators up the island. Transpower has recently commissioned another circuit north of Christchurch to Kikiwa but capacity on the lines running into Christchurch is already stretched and will continue to worsen. Transpower is looking at a number of alternative solutions to this issue. They are proposing a number of small capacity increments using improved bussing and transformer ratings/ capacity in locations such as Islington, Bromley and Ashburton and series compensation of the transmission circuits supplying Canterbury. These projects may culminate in a new transmission circuit from the southern generator region into Christchurch in the future.

Regional Flows

Interregional Flows

During normal operating conditions the Canterbury region receives power from the southern generators. Flows into Canterbury come from the south and flows out head toward the West Coast and north to Nelson and Marlborough. As Canterbury is so dependant on power produced outside of the region having adequate transmission to accommodate the flows servicing local loads is very important. The following diagram shows the typical flow of power from southern New Zealand into Canterbury and further north to Nelson/ Marlborough.

Transmission constraints are the major influence on interregional flows. The risks associated with constraints in transmission include:

- Volatile nodal prices at periods of high demand
- Security and operational issues during normal operation and/or contingent situations
- Lack of investment in industrial/commercial opportunities due to uncertainty of supply and price.

System Risks

A number of factors combined with the system assets create risks in investment, operation and security of the system. Patterns of energy use, interregional flows, age of assets, energy losses and asset utilisation all add to the risks

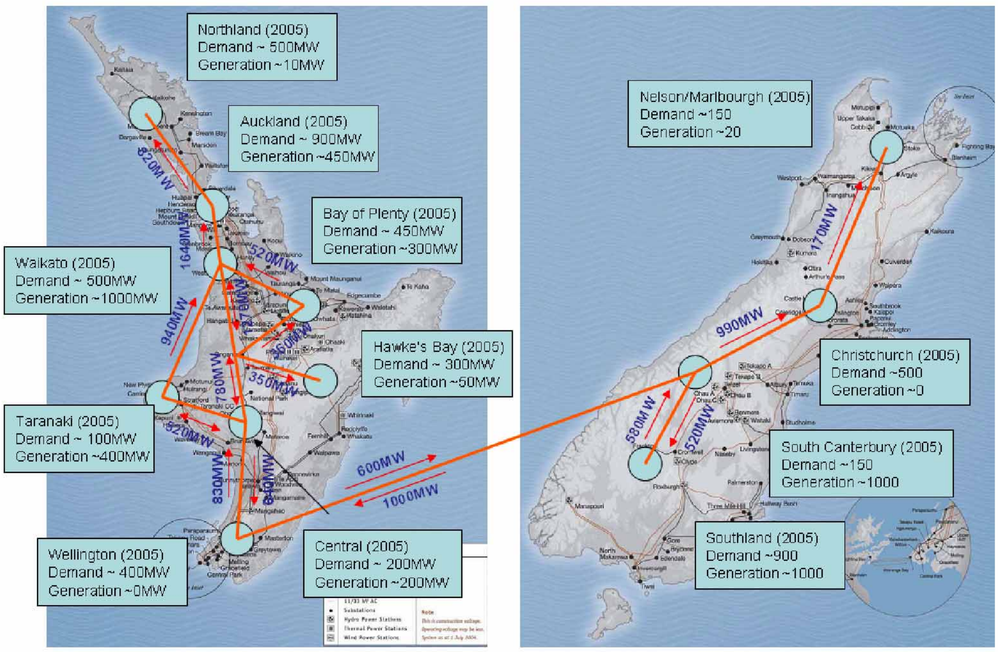

Figure 8: New Zealand core grid maximum transfer capability [Meridian ARTSS Report 2005:3]

the system faces. Quantifying the level of risk to the system will involve analysis for each issue and sourcing the appropriate data.

Patterns of Energy Use

Different types of loads have different effects on the distribution of demand across the day and the year. Residential load has a low load factor and is a big contributor to demand peaks while commercial and industrial loads have high load factors. Other issues for Canterbury surrounding patterns of energy use are irrigation loads which as mentioned previously have a high daily load factor but a low annual load factor. Development of the different types of load growth may need to be predicted in greater detail in order to better plan and/or lobby for the incremental and large scale investments necessary. The risks of not having a good forecast of energy use development include:

- stranded assets from investing in the wrong areas
- small incremental investments becoming superfluous due to necessary large upgrades later on
- system capability being constantly stretched
- Volatility in prices resulting from capacity constraints and uncertain investments.

The information used to track and forecast patterns of energy use will include; annual regional land use plans, energy policies, building consents, population growth, GDP for Canterbury and New Zealand, policies that attract or repel investment in energy intensive industries and long weather predictions (eg climate change, El Nino).

Age of Assets

There is a vast range in the age of assets throughout the networks in Canterbury. Continual upgrade of assets occurs and maintenance schedules are planned accordingly. As assets age they are more likely to:

- Be inefficient causing higher system losses
- Be the cause of faults impacting system security
- Require more maintenance resulting in more outages to get maintenance work done.

While the majority of power system assets are designed to be in active use for 50 years or more they often require partial investment to upgrade their efficiencies or useful lifespan. Older assets require parts that may be hard to source and hence may not be immediately available during fault situations. This results in potentially longer outages, reducing the level of service to customers. The risks of aging assets include:

- Hard to obtain repair parts easily resulting in longer outage times
- Potential lower level of service to customers due to faults and outages resulting in customer loss or complaints.
- An inefficient system.

Gaining an overall impression of the age of assets may be hard to determine as it will vary widely between assets types. Perhaps a more useful measure would be the expected life remaining in assets and whether they are currently scheduled for replacement before their life expectancy is reached. Alongside this, some analysis of the risk associated with assets at their current age, defined in terms of risk of failure causing an outage may be useful in quantifying the risk associated with the asset age. System planners usually take into account many of these age risks when considering upgrade plans for their network.

Energy Losses and Delivery Efficiencies

By reducing energy losses and increasing efficiencies, a greater output (energy utilised) is received for a smaller or similar size input (power generated). Not taking full advantage of fewer losses and greater efficiency results in risks that include:

- Reaching capacity limits faster than necessary
- Wasted energy
- Using more generation resources than necessary.

Potentially resulting in:

- Generation constraints
- Transmission Constraints
- High prices and nodal volatility.

Information on losses and efficiencies is likely to be a combination of the asset design information, the configuration it is used in and the age of the asset. This would give very detailed information for particular areas but a more general approach may be a sufficient level of detail.

A following systems approach would provide a greater insight on a regional level:

Energy in(interregional flow) = energy utilised + energy out(interregional flow) + losses

Asset Utilisation

Asset utilisation is a balancing act between getting a good return on the capital investment, i.e. using the asset as much as possible to improve income, and making sure there is enough spare capacity to accommodate load growth for a suitable period of time. It is the trade off between large scale investment and small incremental investment.

Where the need for an investment to accommodate growth is obvious, fairly certain and economic there is less risk in investing in assets that may not be fully utilised initially. If there is uncertainty surrounding the investment such as the size, location or best improvement to be made, small incremental investments are often useful while the uncertainty resolves itself. The level of uncertainty and hence the risk that is prepared to be taken when deciding on large scale vs incremental may depend on the size and cost of the investment decision.

The risks associated with large scale and incremental investment in terms of asset utilisation includes:

- Low asset utilisation as a result of unrealised growth, overinvestment or large scale upgrades can result in:
  - Stranded assets
  - Wasted capital expenditure
  - Low return on investment
- High asset utilisation as a result of incremental investment or higher than predicted demand growth results in:
  - Greater return on investment
  - The system may face constraints more often, resulting in volatile prices
  - Greater disruption (lost of supply to customers) to the system when the asset is removed during faults or maintenance
  - Harder to find windows for maintenance due to high loading conditions. This may result in longer periods between maintenance than the ideal, increasing the risk of faults.

Information about asset utilisation is most likely to be reflected in system constraints. Assets that are frequently implicated in a system constraint are likely to have high utilisation. Finding assets with low utilisation would require comparing ratings of equipment with average and peak energy flows (or appropriate measure for the asset concerned). Another option for identifying areas that may have high asset utilisation would be studying nodal volatility. High volatility may indicate stretched capacity or constraints and hence high asset utilisation.

These system risks are not well understood particularly with how they relate to and impact on the vulnerabilities of the power system.

6 Level of Service

In determining the appropriate level of service in terms of reliability of supply, it is first necessary to review the regulatory requirements as applied to the grid owner and operator, Transpower. These requirements are summarized in the Electricity Act and Regulations and more specifically in the Electricity Governance Rules (EGR).

Grid Reliability Standard

The EGR's reference the Grid Reliability Standard (GRS) recently developed and issued by the Electricity Commission. An extract from the GRS document is given as follows:

> ***Approach to Grid Reliability***
>
> *2.4 The key role for GRS is to provide a basis, in conjunction with the Grid Investment Test (GIT), for planning and development of the national transmission grid.*
>
> *2.5 The development of transmission networks has, until recently, been largely undertaken according to "deterministic" standards based on network redundancy criteria, often referred to as "N-k". Transpower has applied an "N-1" criterion to its core grid planning, typically seeking to maintain supply during single credible contingencies.*
>
> *2.6 The alternative to this is to adopt a "probabilistic" approach to grid planning and development. This typically involves estimating the probability of contingencies, estimating the expected loss of supply that could occur, and estimating the costs of the loss of supply. Within this probabilistic framework, investments are made in the grid when there is a clear net economic benefit.*
>
> *2.7 Reliability can be defined as definitive planning standards that must be met regardless of economics, or it can be regarded as a target to be achieved provided the required investment meets an economic test.*

The GRS specifies that the EC Board determine the actual grid reliability standards to be applied including the purpose, principles and content of the standards. The standards take into account the Grid Investment Test (GIT) which determines whether a new grid upgrade project is based on sound economic investment criteria. Transpower prepares Grid Upgrade Plans (GUP) for submission to the EC who then determines if the project should go ahead.

The content of the GRS can be based on one or more standards for reliability of the grid and may have a primary standard and other standards to reflect differing circumstances in different regions supplied by the grid. The clauses of the GRS thus do not apply prescriptive rules for reliability standards but allow for a number of different levels of reliability across the power supply network. It is thus up to the grid planner and operator, Transpower, to determine which reliability standard should apply to the core grid with regional interests having an input into the decision for their specific areas.

Transpower's Reliability Standards

Transpower's reliability standards are described in a March 2005 document entitled North Island 400 kV Project, Main Transmission System Planning Criteria. The document refers to transmission system reliability as incorporating assessment of two basic aspects of the system; adequacy and security, as defined by the North American Electric Reliability Council (NERC) in the USA. The NERC document defines these terms as:

Adequacy as "The ability of the electric systems to supply aggregate electrical demand and energy requirements of their customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements"

Security as "The ability of the electric systems to withstand sudden disturbances such as electric short circuits or unanticipated loss of system elements."

Transpower has added another two terms to describe system reliability when considering the state of the transmission system. These are:

Satisfactory State when "The transmission system can supply aggregate electrical demand and energy requirements of their customers at all times." and

Secure State when "The transmission system can satisfy the test for system *adequacy* for all reasonably expected conditions including scheduled and unscheduled outages of system elements and return to a *satisfactory state* after a sudden disturbance."

Transpower's reliability standard is based on the deterministic approach as described in the GRS above. This approach, which is applied worldwide, is further described:

> *"The main interconnected transmission system shall be planned and developed to maintain N-1 security criterion, meaning that the system is in a secure state with all transmission facilities in service and in a satisfactory state following credible single contingency events……The loss of an element could be either planned (as part of scheduled maintenance) or unplanned (as an unforeseen event) either by inadvertent disconnection or as a consequence of a fault occurring in/on the affected element."*

Transpower plans and operates the grid to the n-1 security criterion and consequently this measure is a significant contributor to any upgrade plans that are developed.

Furthermore, Transpower assesses the n-1 security of the grid in accordance with the Electricity Commission's Electricity Governance Rules (EGR), particularly Schedule F3 of the EGR's "Grid Reliability Standards" (GRS). Clause 4 of the GRS states that:

> "*For the purpose of clause 3, the* ***grid*** *satisfies the* ***grid reliability standards*** *if:*
>
> *4.1 the power system is reasonably expected to achieve a level of reliability at or above the level that would be achieved if all* ***economic reliability investments*** *were to be implemented; and*
>
> *4.2 with all* ***assets*** *that are reasonably expected to be in service, the power system would remain in a* ***satisfactory state*** *during and following any* ***single credible contingency event*** *occurring on the* ***core grid***."

In Part A, Interpretation, Section 1 Defined Terms, of the EGRs it defines a single credible contingency event as:

> "***single credible contingency event*** *means an individual credible contingency event comprising any one of the following:*
>
> *(a) a single transmission circuit interruption;*
>
> *(b) the failure or removal from operational service of a single generating unit;*
>
> *(c) an HVDC link single pole interruption;*
>
> *(d) the failure or removal from service of a single bus section;*
>
> *(e) a single inter-connecting transformer interruption;*
>
> *(f) the failure or removal from service of a single shunt connected reactive component;*"

In line with the GRS, Transpower does not consider a tower failure as a single credible contingency event and in particular does not consider the loss of a double circuit line as a single credible contingency event.

Also, in line with the GRS, Transpower does not consider the loss of a whole substation to be a single credible contingency event. However, Transpower is currently reviewing the security of Islington and Twizel Substations, among others, and it may be that in a future grid upgrade plan that the low probability, high consequence event involving the loss of either substation may warrant some form of mitigating measure.

However, there is an exception to the n-1 criterion where Transpower has further elaborated on its reliability obligations in its Annual Planning Report issued in June 2006 as follows:

> Transpower considers that in some situations generation assets cannot reasonably be expected to be in service. Specifically, for major load centers that are dependent on local generation for supply security, Transpower plans to an n-g-1 reliability level.
>
> That is, the system remains in a satisfactory state following a forced outage of:

- *any transmission component (see single credible contingencies below); and*
- *an outage of the single largest generator.*

As a result, Transpower considers the following interpretation falls within the definition provided:

Auckland is an example of where an n-g-1 planning standard is used because of the comparative low reliability of generating plant (thermal plant in particular), the criticality of that generation for Auckland, and the size of the Auckland load.

Consequently, a review of the EC's GRS for single credible contingencies may be appropriate to cover the above cases where a true n-1 criterion is not satisfied for all contingencies as outlined in the EEA Guidelines and the ODV Manual.

In terms of the EGR Section 12A, Transpower has included a review of the main grid n-1 security criterion in Appendix A3 of its Annual Planning Report for 2006. A summary of the review is provided later in this report in the Table of Backbone Issues and Resolving Projects. However, a more detailed evaluation of n-1 adequacy and security criteria for each regional GXP may have to wait Stage 2.

Standards for Security of Supply in New Zealand

Each market participant has the ability to plan and operate their assets to supply their own desired level of security. There is currently no standard that must be applied uniformly across the system, only guidelines that companies may pick and chose as to what they implement. A useful basis for guidelines on security of supply is the document produced by the Electricity Engineers Association (EEA) in June 2000 entitled "Guidelines for Security of Supply in New Zealand Electricity Networks". The Guidelines state that they are not intended to be mandatory but, in the opinion of EEA, they are considered to be good practice for application in New Zealand. They are specifically intended for distribution network or lines companies and can be used for their Asset Management Plan disclosures under the Electricity Act (Information Disclosure) Regulations. The Guidelines were developed after the Ministerial Inquiry into the Auckland Central Business District power failure in 1998 recommended that guidelines be prepared for security of supply in New Zealand electricity networks.

Table 5 (overpage) provides the Security of Supply Guidelines as developed by the EEA:

The Electricity Commission has recently completed a review of grid security including consultation with electricity industry participants and major customers. The review concluded that loads above 150MW must have N-1 security and that loads below 150MW will be subject to probabilistic economic analysis on a case-by-case basis. While the EEA guidelines provide a basis for companies to base their security criteria on, they are by no means universally adopted throughout the country. Regionally it may be that the guidelines do not adequately reflect the security requirements of different load types as many areas have unique demand profiles.

System Economic Valuation Methodology

The 2005 Report of the Optimised Deprival Valuation (ODV) of Transpower's System Fixed Assets as at 30 June 2005 has the following relevant comments:

> *"At present the security standard applied by Transpower to consumers, Distribution Line Businesses (DLBs), and other large private industrial consumers differs significantly from area to area, but in general follows the (n - 1) criterion, with security to the (n - 2) level only used for a small number of specific industrial consumers. Table A3.1 below shows the security guidelines for transmission equipment planning.*
>
> *Moreover, a substantial number of smaller supply points are provided with power through either one transmission line or one transformer; either element controlled by a single circuit breaker will meet just the (n) criterion.*
>
> *Examination of the existing system indicates that in many instances the (n - 1) criterion is not met."*

Class Of Supply	Range of Group Peak Demand (GPD) MVA	Typical Examples	Minimum Demand to be met after First (Tx/cct) Outage	Minimum Demand to be met after Second (Tx/cct) Outage
A	0 - 0.5	Customer Connections Urban Low Voltage meshed distributor.	Repair Time (Note 1) 100% GPD	Repair time (Note1) 100% GPD
B	0 - 1.5	Rural radial feeder Urban small radial feeder.	Repair time - 100% GPD	Repair time - 100% GPD
C	Up to 12	Rural meshed network. Rural district substation. Urban meshed network (open rings) Rural GEP's.(Note 5)	Within 3 hours - 50% GPD Note 2 In Repair time - 100% GPD	Restoration, Or in repair time - 100% GPD
D	over 12 - up to 60	Urban closed ring networks, district substations, major switching stations.	Immediately - 100% GPD less 12MVA. Remaining 12 MVA - 3 hrs	Restoration Or in repair time - 100% GPD
	Over 12 - up to 40 (Remote Point of Supply)	Remote Region GEP's/district substations	Switching time - 75% GPD Repair time - 100%	Restoration Or in repair time - 100% GPD
E i	60 – 200	Large industrial customers. Major city CBD's	Immediately - 100% GPD less 12 MVA. Remaining 12MVA - 3 hrs.	Within 1 hour - 100% GPD less 12MVA. Remaining 12MVA - 3 hrs
ii	40 to 300 (Normal Point of Supply)	Normal GEP's (dual circuits/transformers)	Ditto	Switching time - 100% GPD less 12MVA, Remaining 12MVA - 3 hrs
F	300 - 600	Larger GEP's:- Three circuits (on two routes); Three busbars; Two or more transformer banks.	Immediate 100% - GPD	Switching time -100% GPD
G	>600	More than one major terminal substation in region. Note 3.	Immediate 50% - GPD Switching 100% - GPD	Switching time - 100% GPD

Notes:

1) The timescale for the repair/provision of temporary supply should be set as part of the Line companies Service Level Guidelines. See also clause 9.1.6.
2) In remote areas it may prove uneconomic to provide any switched alternative supplies to very small, (<12 MVA) GEP's.
3) For example, two or more GEP's in region, only one supply (or it's equivalent) should be lost on the first outage.
4) This table must be read in association with the rest of the Guideline document particularly in relation to the application of the analysis of a network and the resolution of
5) GEP - Grid Exit Point.

Table 5: EEA "Normal Security of Supply Guidelines"

It is noteworthy that the following table from the ODV Handbook resembles that in the EEA Guidelines with loads over 600MW requiring more than one major terminal station for supply in the region. According to the EEA Guidelines and the ODV Handbook, both Auckland and Christchurch do not comply with this criterion. Transpower is taking steps to provide an improved n-1 supply to the Auckland CBD by arranging to feed the new 400kV transmission line directly into the Pakuranga substation and not Otahuhu substation as originally planned. This should satisfy the n-1 substation criterion for loads over 600MW. Presently nearly all the supply into Christchurch comes through Islington substation. Christchurch is not as vulnerable as Auckland as the system can supply about 50% of the Christchurch load through another substation at Bromley though the n-1 criterion is still violated for the Canterbury region.

Orion's Security of Supply Standard

An internal report on Orion's Security of Supply Standard (SSS) Review in September 2006 highlighted very useful information about the system in the Canterbury region.

Orion believes that its present SSS should be modified to account for the optimum balance between its network costs and the Value of Lost Load (VoLL) to its customers.

It is anticipated that the revised SSS will produce savings on capital investment but will also slightly reduce the reliability performance of its new substations. Orion believes that this reduction will not be material and its overall reliability performance will still be better than most other lines companies in New Zealand. The savings produced with this approach will allow increased expenditure on maintenance and operations. Orion's revised SSS will be a mix of a refined deterministic N-1 criterion and

Load (MW)	Basic Security	Transmission Circuits	Busbars	Transformers
Less than 10	n	One circuit	One bus or bus section	1 x 3-phase units
(10 to 40, if more than 40 km remote and local generation can limit load shed to 25%)	n	One circuit	One bus or bus section	4 x 1-phase or 1 x 3-phase unit, if backed up from alternative supply point
From 10 to 300	n-1	Two circuits	Two busbars or bus sections	7 x 1-phase units or 2 x 3-phase units Firm supply of peak demand using any short term overload capability
More than 300	n-2	Three circuits on at least two routes	One redundant bus or bus section, such that supply is not lost after a single contingency while one bus is out of service for maintenance	7 x 1-phase units or 2 x 3-phase units Firm supply of peak demand using any short term overload capability
More than 600	Loss of station.	Supply into a region should be diversified across more than one major terminal substation		

Table 6: ODV "Security Guidelines for Transmission Equipment Planning"

a probabilistic evaluation based on the VoLL approach for major customers. The SSS will also specify times for various sizes of loads within which supply should be restored following different numbers and types of faults. It is hoped this will give a better balance between cost and reliability. This is also in line with the time based approach in the EEA Guide.

Orion has a separate security arrangement in rural areas. The majority or rural load is irrigation and security arrangements for this load are based on Orion's interruptible irrigation policy. Rural security is covered in Orion's revised SSS as follows:

> *"Rural network capacity is dominated by the requirement to meet irrigation load growth. The value of electricity to irrigators has been assessed by 'Agri Business' and the findings presented to a representative irrigation group. Following this consultation, Orion has updated its interruptible irrigation policy. . It is for this reason that the urban security MW thresholds have been applied to the rural network with slightly increased switching/ restoration times reflecting the increased travelling times involved. Over time, it is anticipated that the rural customer mix will change as Rolleston and Lincoln residential development occurs and it would be prudent to reassess the rural economic analysis on a regular basis (3-5 years)."*

Power Quality

Power quality is defined by a group of attributes that reflect the performance of the electrical power supply. The three most important power quality attributes that can be controlled by regional distribution companies are:

- steady state voltage supplied to consumers;
- level of harmonics or distortion of the power supply; and
- number and magnitude of transient voltage excursions.

Regional distribution companies can only control the power quality to their customers to the level of power quality that the distribution company receives off the grid. That is, should the grid power quality be poor then the distribution company cannot do much to improve the supply they receive and ultimately pass onto their own customers. Each network contracts with Transpower for a particular power quality at GXP's

Steady state voltage

Steady state voltage is mandated by regulation as 230Volts ±6%.

Unanticipated consumer loads are the largest contributing factor to voltage excursions. Orion has a target voltage quality level of no more than 70 proven complaints per year

Transpower allows for a ±10% violation on the 220kV and 110kV grid. This standard was exceeded once during the time period March 05 and February 06.

Harmonics and Distortion

Harmonics or distortion are most often introduced to the system through connection of electronic equipment. The level of allowable harmonics is mandated by regulation and Orion uses harmonic allocation methods defined in IEC/Joint Australian/NZ standards to determine acceptable consumer levels of harmonic injection. Most problems and complaints from customers are a result of connected equipment owned and operated by the complainant. Where this is the case Orion will investigate and may require the offending equipment to be removed from the system.

Transient Voltage Excursions

Transient voltage excursions vary in frequency and magnitude. They are often referred to as sags, swells, surges or flicker. The Orion network is operated to a joint Australian/New Zealand and international standard and the effects of voltage excursions are aimed to be minimised.

Common Quality Obligations

In Section II of the EGR, issued on 8 June 2006, the principal performance obligations of the system operator are to:

> *"2.1 Avoid cascade failure*
>
> *Act as a reasonable and prudent system operator with the objective of dispatching assets made available in a manner which avoids the cascade failure of assets*

resulting in the loss of demand and arising from frequency or voltage excursions and supply and demand imbalances."

The standard discusses other quality of supply issues which include; managing time errors, limiting harmonic levels, limiting voltage flicker levels and voltage imbalances giving rise to negative phase sequence voltages and currents in the network.

Transpower in its role as system operator must also regulate the frequency of the system. The standards that it must meet are to keep frequency between 49.8 – 50.2 Hz. This is done by contracting generators to be the frequency keeper. There is one for the north island and one for the south island. Excursions from this frequency band are recorded by Transpower. The excursions from Mar05 – Feb 06 are shown in the following table.

Overview of Transpower and Orion Supply Quality

The following extract from Transpower's Annual Report for 2005/2006 gives the main system availability and system minutes lost for the year to 30 June 2006. Apart from the Auckland outage on 12 June 2006, which contributed 29.8 system minutes, the overall results were close to target.

The following extract from Orion's Network Quality Report for 2006 indicates that Orion's performance is one of the best in New Zealand and compares favourably with international results for the same criteria.

Table 9: Distribution Network System Reliability [Orion Network Quality Report 2006:4]

Trends in Orion's supply quality can be summarized by the measures of SAIDI and SAIFI. These two measures are defined as:

- SAIDI, or System Average Interruption Duration Index, measures the average number of minutes per annum that a consumer is without electricity.
- SAIFI, or System Average Interruption Frequency Index, measures the average number of times per annum that a consumer is without electricity.

Extreme weather events can have a large impact of the recorded SAIDI and SAIFI measurements of a network and so it is more informative to look at the long-term trends of

New Zealand System Frequency Performance	Year 2005										Year 2006		Cumulative total last 12 months	Rolling Annual Freq. Perf. Obj. (PPO)
Frequency Band (Hz)	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb		
55.00 > Freq >= 53.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
53.75 > Freq >= 52.00	0	0	0	0	0	0	0	0	0	0	0	0	0	2
52.00 > Freq >= 51.25	0	0	0	0	0	0	0	0	0	0	1	0	1	7
51.25 > Freq >= 50.50	3	2	0	0	0	0	1	0	0	0	0	0	6	50
50.50 > Freq >= 50.20	133	111	183	239	288	227	214	139	115	124	96	82	1951	-
50.20 > Freq > 49.80	Normal Frequency Band													
49.80 >= Freq > 49.50	106	173	212	250	294	221	201	173	137	157	121	124	2169	-
49.50 >= Freq > 48.75	5	0	1	1	4	4	6	3	1	9	1	2	37	60
48.75 >= Freq > 48.00	0	0	0	0	0	0	0	0	0	1	0	0	1	6
48.00 >= Freq > 47.00	0	0	0	0	0	0	0	0	0	1	0	0	1	0.2
47.00 >= Freq > 45.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2

Table 7: NZ System frequency Performance 2005 [Transpower]

System Reliability Measures Actual	2005/06	Target 2005/06
High Voltage alternating current (HVAC) availability	98.6%	98.9%
High Voltage direct current (HVDC) availability - overall Pole 1 Pole 2	95.2% 92.0% 98.7%	94.0% 92.5% 95.6%
Unplanned Supply Interruptions	38 system minutes	<9.0 system minutes

Table 8: Transmission Network System Reliability [Transpower]

these figures. Orion's AMP illustrates their network's performance in the graphs shown in Figure 9.

A comparison with national and international utilities is provided in the following extract from Orion's 2006 Network Quality Report. It is reassuring to note that the reliability of supply to the Christchurch CBD is secure with alternative routes and other sources of supply. Unfortunately the >600MW load criterion for n-1 substations in a region is still not completely satisfied as outlined previously in the section on Standard of Security of Supply.

Our research into national and international comparisons indicates that our urban network reliability is above average while our rural network reliability is slightly below average. We also measure the reliability of our supply to the central business district (CBD) area of Christchurch. A reliable electricity supply is critical to the CBD area given the economic impact of any electricity outage6. Consequently, our supply to the CBD is very secure with a number of alternative sources available to restore supply in the event of a fault. The level of reliability witnessed by Christchurch's CBD is in line with that of Australian cities. Unfortunately New Zealand CBD figures are not available for comparison as, to the best of our knowledge, Orion is the only New Zealand network company to publicly disclose CBD reliability statistics.

Table 10 compares Orion's performance in the Christchurch CBD relative to a number of CBD's in Australia. The figures suggest that Orion compares well with Melbourne and Sydney while Brisbane performs much better.

Overall it appears on past performance that both Transpower as System Operator and network companies achieve the performance targets for power quality that they set out for themselves or by regulation. Intuitively a constrained system would make these targets more difficult to meet and should the system become constrained over a long period of time, it would be expected that this stretching of system capacity would be reflected in the ability to maintain power quality. While power quality targets and related violations can be used as an indicator of a highly constrained system it is widely acknowledged that system security measures give the earliest warnings of impending system constraints and stretched capacity. The following section investigates security measures and vulnerabilities for Canterbury.

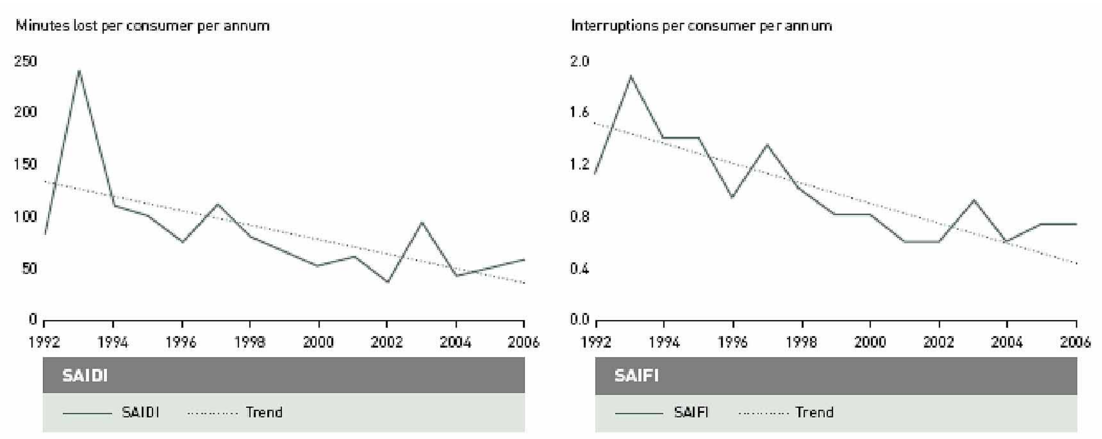

Fig 9: Network Performance [Orion Network Quality Report 2006:6]

	SAIDI*	SAIFI*
Christchurch CBD	10	0.16
Brisbane CBD	2	0.03
Hobart CBD	36	0.35
Melbourne CBD	10	0.10
Sydney CBD	17	0.40

* Based on latest available year figures (5 year averages not available); Excludes transmission outages and adjusted for extreme events in accordance with Australian reporting standards.

Table 10: International Comparison of Distribution Network Performance [Orion Network Quality Report 2006:9]

7 SECURITY OF SUPPLY

System reliability can be considered to be the summation of system adequacy and system security. Adequacy and security are conceptually different. Security is the ability of the system to continue supplying load under a fault situation whereas adequacy is the ability of the system to supply loads under different operating conditions and provide adequate capacity in the system to provide reasonable cover for unseen events (e.g. dry years, cold weather). This section focuses on planning for security, the measures used and the vulnerabilities in security in Canterbury.

Security can be defined in many ways and the level of security planned and invested for can be different in different regions. Based on the current n-1 security criteria used for planning by Transpower a number of vulnerabilities in security are seen in the Canterbury region at the core and non core grid level. These vulnerabilities in the grid are highlighted by the differences in security criteria at distribution network level. Distribution networks often have alternative security standards for different load groups that don't necessarily match the security criteria of n-1 used by Transpower.

System adequacy is addressed in the ECs Statement of Opportunities (SOO) document and is also considered by the region's network companies in their Asset Management Plans. The system adequacy aspects for the Canterbury region will be covered in the following section on the Regional SOO.

Security Planning Criteria/ Measures

Security planning can be undertaken in two ways, either probabilistically or deterministically. Deterministic planning is the type used by Transpower and is a deterministic standard such as n-k where supply is maintained during credible contingencies. Transpower uses an n-1 criterion for the core grid with the exception of Auckland that has a n-g -1 criteria. The 'g' refers to local generation that is relied on to provide security of supply. Probabilistic planning typically involves estimating the probabilities of contingencies, estimating the expected loss of supply and the resulting costs from this loss of supply. Using probabilistic planning, investments are made when there is a clear net economic benefit.

Either method of security planning has its place but probabilistic planning has a major hurdle to overcome. This is the way in which a value is placed on the load lost during an outage. This value of lost load or VoLL is very different across the country, within regions and across load types. Being able to quantify this VoLL value is extremely important in having an accurate probabilistic planning process.

Value of Lost Load

The Value of Lost Load (VoLL) is a measure of the value of unserved energy. While current practise plans to maintain core grid security to a deterministic n-1 criterion there are some suggestions that using VoLL may give a more useful measure in order to plan for security of supply.

Using VoLL gives an indication of the willingness of consumers to forgo their electricity supply in an adverse event. If consumers have a low value of VoLL, they are prepared to wear the risk of having supply interruption and hence are unlikely to wish to pay for n-1 security investments. Alternatively some consumers may have a very high VoLL e.g. hospitals so they will either willingly pay for increased security or provide their own backup systems. While this use of VoLL seems to be a suitable solution to the security issue, there are two main drawbacks. The first being that currently there is an inconsistent value for the VoLL across the system and secondly that providing differing levels of security within a meshed urban system is a very complicated prospect, if not impossible.

The following table illustrates data extracted from Orion's internal document, Security of Supply Review.

These differences illustrate that different loads have a different risk acceptance regarding

	VoLL ($/kWh)
Orion	$13.72 + $6 /kW VOI
CAE (Sep 2004)	$17.17
Electricity Commission	$20.00
VENCorp (Victoria, Australia)	$29.60 Australian dollars

Table 11: VOLL

security of supply. An issue for consideration with these values particularly between Orion and the EC is that Orion values the unserved energy at a lower value than the EC. This has security planning implications when considering the value of unserved energy in the Canterbury region.

Transpower and the EC use the value of $20,000MWh ($20/kWh = $20,000/Mwh) for unserved energy or VoLL but Transpower uses a deterministic n-1 planning criteria for investment rather than unserved energy. In recent feedback to the Electricity Commission on the GRS it was noted that:

- Several submitters (in particular Contact, Meridian, MRP, Vector) note that not every MWh of unserved energy has the same value, and that different types of customers will value MWh differently at different times. The frequency, depth and duration of unserved energy also have bearing on the value, as does the timeliness of notice of impending outage.
- Meridian suggests that the use of a value of unserved energy is a bias towards reliability at grid exit points, and that a cost of un-dispatched energy should also be incorporated. Meridian also seeks clarification as to how the proposed value of unserved energy of $20,000/MWh is reconciled to the value of security of supply, the trigger price for reserve energy, and the standing offer price for reserve energy at Whirinaki.
- Some submitters (in particular Northpower) consider that the assessment of unserved energy needs to be broadened to include the total costs of disruption, and not just for the duration of the outage. Additional costs might include, for instance, lost production time restarting machines and destroyed product.

The EC suggests that it will undertake a review of the nature and value of unserved energy in the next 2 – 3 years.

System Operator Security Requirements

Transpower as System Operator is responsible for managing the system security constraints on a real-time basis and for notifying customers of any issues before they arise. If constraints are breached then official notices are required to be issued and these are notified on Transpower's website. It is interesting that currently there are over 600 constraints on the main transmission system and it is Transpower's intention to reduce this number through Grid Upgrade Projects (GUP) as soon as practicable. The constraints put upon the system are designed to ensure that the system can provide a certain level of power quality and security, to ensure safe operation of the system (i.e. to ensure cascade failure doesn't occur) and to operate the system in an economic least cost fashion. The Grid Reliability Standard (GRS) is soon to be published by the EC and received a number of submissions relating to n-1 security and the real time operation of power system.

In a recent submission to the EC on the GRS Transpower noted the following:

> *"it is critical that planning standards and those for system operation are consistent… Given the widely different timescales of grid planning versus system operation, and the typically regional focus of the former but national focus of the latter, system operation standards should be an input to grid planning but not vice versa."*

The system operator is required to invest to maintain n – 1 security and to operate the national grid with n -1 security in real time. Meridian noted in its submission that:

> *"the operational aspects and the System Operator Policy Statement should reflect the GRS… Once decided, the System Operator should be required to deliver to the planning standard in an operational sense and no higher… There is a significant risk that if… customers select a probabilistic reliability standard which is less than N-1, that the System Operator will continue to operate to N-1 in real time. This may yield significant price constraints, constrained on generation and additional cost to the energy market that is not*

required or desired by the connected customers."

That is the operational policies should reflect the security level defined in the GRS and not the opposite.

Security of Supply and Vulnerabilities

Transpower's Annual Planning Report provides a useful summary of the requirements and issues being faced in delivering a secure supply of electricity from the national grid and specifically from Grid Exit Points (GXP) in the North and South Islands. Only the South Island transmission system and security incidents will be covered here.

Grid Reliability and Security Issues

Transpower's Annual Planning Report for 2006 incorporates the Grid Reliability Report as required by the EGR's and provides a useful summary of issues that impact on n-1 supply security in the South Island. The EGR require that Transpower's Grid Reliability Report details

"whether the power system is reasonably expected to meet the N-1 criterion and in particular whether the power system would be in a secure state at each grid exit point, at all times over the next ten years, having regard to the possible future scenarios set out in the statement of opportunities."

The issues impacting n-1 as Transpower defines that term are listed in the table below together with the planned projects aimed at resolving those issues.

Addressing Security Vulnerabilities in Canterbury

The process for addressing vulnerabilities in the Canterbury region was summarised by Transpower at the first CRESG Workshop on 7 September 2006 as follows:

- Transpower has indicated that supplies to the upper South Island region could become constrained by 2012.
- Through the RFI released last November, Transpower requested information from interested parties on alternatives for meeting supply security past 2012.
- Transpower has communicated its request through
  - Industry forums held at Christchurch, Nelson, West Coast
  - Presentations to the city councils, regional councils, chambers of commerce and other leading public organisations
  - Public advertising on release of the document and encouragement of submissions

Transmission Capacity into Top of South Island and West Coast	▪ Third 220 kV Islington – Kikiwa circuit
Transmission Capacity north of the Waitaki River	▪ Replacing the conductor on the 220 kV Islington-Livingstone circuit ▪ Bussing the 220 kV Islington-Twizel circuit at Ashburton ▪ New 220 kV capacitor banks at Islington ▪ New 220 kV capacitor banks at Ashburton ▪ New Transmission Line into Christchurch
Transmission capacity through the Waitaki Valley	▪ Replacing the conductor on the 220 kV Aviemore-Waitaki-Livingstone circuits ▪ Thermal upgrade of the 220 kV Aviemore-Benmore 1 and 2 circuits ▪ Thermal upgrade of the 220 kV circuits between Benmore and Twizel
Transmission Capacity into Lower South Island	▪ Capacity upgrade of the 220 kV Livingstone-Naseby and Naseby - Roxburgh circuit OR ▪ New transmission line between Roxburgh and Twizel
	▪ Power system stabilisers on generators south of the Waitaki Valley
Condition of HVDC pole 1 converter equipment	HVDC Pole 1 replacement
Condition of HVDC Control Systems (pole and Pole 2)	HVDC Control System replacement (2010)
Condition of 350 kV submarine cables	HVDC Submarine cables (2010)

Table 13: A.3.1 Backbone Issues and Resolving Projects (South Island)

- Written submissions were received between November 05 and late February 06.

The voltage stability constraint is more limiting (on the amount of power transmission) than line thermal ratings. It is very important to confirm the load composition and performance under low voltage using dynamic analysis. This will determine if a voltage stability constraint could occur.

The following responses were received through the RFI process:

Supply Side Options:

- Only two specific supply side proposals were received and both proposals concentrated on installing diesel generators up to 40 MW.
- Other possible options for local generation included
  - Small hydro
  - Landfill Gas
  - Wind farms
  - Co-generation
  - Coal fired thermal

Demand Side Options:

- Two specific demand side proposals were received
  - Some short term relief through demand shifting between GXPs
  - Demand reduction through demand management up to 73 MW
- Other possible options included:
  - Energy efficiency initiatives

Transmission Options:

- Tapping off electricity from the HVDC line near Waipara (however, this option has some technical and cost issues and Transpower is currently considering advice obtained from a New Zealand HVDC expert)
- Transpower has also been analysing the possible incremental options for grid upgrades that would allow deferment of major transmission investment such as:
  - Bussing of the 220 kV transmission lines supplying USI at Geraldine (effectively reducing the impact of outage of a line) and shunt reactive compensation
  - Series compensation of the transmission lines (effectively shortening the length of the lines)
  - Major transmission investment (ie. new transmission line) between Waitaki and Christchurch.

To summarise, the most feasible Options as Transmission Alternatives were:

- Installation of diesel generators in the USI up to 30 MW
- Demand management (including efficiency increases) up to 73 MW.

These options are presently being investigated by Transpower who recently released a press statement saying that due to the submissions received for alternatives to its proposed transmission upgrade, the upgrade may be able to be deferred for an even longer period of time.

Transmission Planning and Regional Benefits

The EC principle objectives are:

- To ensure that electricity is produced and delivered to all classes of consumers in an efficient, fair, reliable and environmentally sustainable manner
- To promote and facilitate the efficient use of electricity.

In addition to meeting its principle objectives the government expects the EC:

> *...to take into account and contribute as appropriate to the Government's wider policy objectives.*

Those policy objectives include climate change policy, the RMA and the National Energy Efficiency and Conservation Strategy

One way the EC fulfils their principle objectives is by administering the Grid Investment test (GIT). Transmission planning must pass the GIT before the plan can be approved. It seems that the GIT process as it currently stands fails to include a number of factors in determining an appropriate investment path going forward. A submission to the EC on Transpower's 400kV investment proposal for Auckland by The Energy Centre at the University of Auckland highlights a number of areas that the GIT appears to ignore in the investment test. The issues ignored by the GIT highlighted by the submission include:

- The GIT ignores the effect different transmission decisions have on resulting generation scenarios. Analysis of generation scenarios resulting from transmission decisions is missing from the GIT and could have a direct effect on Climate Change obligations or the National Energy Strategy. An example being where a deferred transmission investment results in installation of a thermal generator resulting in CO_2 emissions. The GIT ignores the potential impact of this new generation.
- Optimal generation investments (and costs) benefit from a reduction in risks and uncertainty; and hence from longer-term certainty and security regarding transmission pathways. Transmission deferral does not create certainty.
- The GIT as presently applied misses or underestimates some important benefits, especially concerning the competition benefits of 'excess transmission capacity'.
- Generation and transmission investments are interdependent in that transmission investments can affect types, sizes and locations of generation investments and vice versa. This is not currently recognised in the GIT.
  These issues surrounding the GIT are very relevant for the Canterbury region. Sustainability, interdependence of transmission and generation and the transmission capacity influencing competitive market behaviour are some of the important issues in planning for investments to ensure security in the system. The GIT also does not appear to take into account certain social and community issues surrounding the NIMBY (not in my back yard) factor. An example where these issues had an overriding effect on project viability was Project Aqua, which was cancelled when well into its design phase. Issues such as environmental impact of large transmission towers and the value of land for servitudes are difficult to cost for the GIT. The various parties involved will have quite different opinions of what these subjective but significant quantities should be. Other areas identified that need to also be considered in the planning process are discussed in the following sections.

Market/Risk Vulnerabilities

- Planning for n-1 security on the grid doesn't appear to allow enough flexibility to mitigate nodal risk. This can result in constraints and influence price spikes.
- The market is supposed to deliver investment signals through prices but either this signal is not occurring or it is not occurring in enough time to plan investment before security becomes an issue. Price signalling also has the effect of reducing demand growth. While Orion does do this to some extent more could be made of the ability to influence demand by providing price information to consumers.
- One issue yet to be resolved is how market price signals for short term, but relatively high cost supply constraints can be commercially contracted to ensure long term system performance. For example, how will a local embedded generator contracting for the supply of grid capacity support also provide the required pricing risk cover to all grid loads affected by any future failure of this service?
- Canterbury could benefit from 50MW of peaking plant in order to delay transmission investment. This investment itself is not economic but incorporating the savings by delaying transmission investment it is economical. Transpower as grid owner saves money by not investing but the region doesn't receive this saving to put towards the cost of installing peaking plant. As noted above, for the peaking plant owner to provide an alternative to transmission, there needs to be an economic cost recovery from the grid owner or market, and the market needs access to a transmission price hedge for the constraint being managed.
- The market system tends to favour small incremental investments. In a perfect market situation these incremental investments would be guaranteed to occur and a perfectly balanced system would result. In reality, uncontrollable delays such as the RMA consent process can cause each incremental investment to fall further behind when it is needed. As each incremental investment is delayed the ability of the system to cope with the shrinking reserve margin (offered capacity – demand) is reduced. This is where the system starts to be constrained. A suggestion to mitigate

this issue is to use the advantages of economies of scale and combine increments into a larger investment. There is a risk that the current market investment model doesn't put enough emphasis on the benefits of economies of scale and hence the overall system is suboptimal.

- The risks associated with incremental investment include:
  - Capacity in the system is always stretched as investments are small and "just in time".
  - Price volatility and nodal risk is high
  - Much more difficult to plan for large investments due to uncertainties in the future being too hard to quantify satisfactorily.
  - Economies of scale may be lost when they could be used to overcome the uncontrollable delays occurring in incremental investment.
- The risks with large scale investment include:
  - 'gold plating' the network
  - Inefficient use of capital
  - Stranded assets when demand or supply doesn't eventuate
  - Price volatility is low – this is not a risk but the true cost of electricity may not be transparent.

The risks between incremental and large scale investment are a balancing act between efficient use of capital and ensuring adequate capacity and security to facilitate regional growth.

Many of these risks do not have an immediately identifiable solution to address the vulnerability. Most solutions result in a trade off between risk and investment and it depends on the companies involved as to how much risk they are prepared to accept.

Nodal Risk

Operational issues such as managing n-1 security on the transmission system into the Canterbury region can result in Grid Emergency Notices being issued. These notices have a tendency to induce price spikes and hence increase nodal risk. This risk most affects the retailers and consumers rather than the transmission owner and results in concerns that planning for and operating to a n-1 security level doesn't allow enough flexibility to manage nodal risk successfully. Supply to Christchurch needs to be improved by 2008 in order to continue meeting the n-1 security standard but anecdotal evidence suggests that nodal risk will be very high before this time.

Nodal pricing risks are a combination of two things: Nodal loss factor of core grid, know as ACLF (AC Loss Factor); and nodal constraint factor made up of system constraints and price differentials. The nodal loss factor can be quite high when it is considered that the geographic load centre is situated near to Hamilton and the geographic generation centre is at Benmore. Data supplied by Meridian indicates that nodal pricing risks can range from 13 – 20% of nodal $/MWh prices. Based on an average wholesale price of $65/MWh, pricing risks can account for between $7 – 14/MWh. This is a high value risk when the normal price net margins for retailers are in the order of $3 – 5/MWh in present market. The $7 – 14/MWh nodal risk, if unhedged may swamp the normal net retail margin and be unprofitable leading to retailers reconsidering their growth options in regions with high nodal risk. It will depend on the availability of constraint hedges and/or the risk acceptance of the individual retailer as to whether they continue to trade in an area with high nodal risk. In either case, the consumer is likely to pay a risk margin for the constraint and in many areas this margin may well be higher than the transmission or network avoided upgrade costs.

Where the nodal risk is greater than the profit margin at a node, the node becomes more unprofitable and market participants tend to shy away from supplying load at that node. It will depend on the risk acceptance of the individual retailer as to whether they continue to trade in an area with high nodal risk.

Supply Chain Risk

The overall supply chain needs to work cohesively so that no one part of the chain puts undue risk on the electricity supply to the region. The supply chain consists of generation, transmission, distribution and retail. With each part of a supply chain ideally being equally responsible for security, assessment of the current situation in Canterbury would be a useful planning tool to show the various strengths and weaknesses. This would allow for appropriate investment in different areas.

Whilst South Canterbury is a major exporter of electricity to the North Island, Canterbury has very little generation, so the focus for security of supply is on the transmission system. If no generation is installed it may be appropriate to ensure security of supply by investing in the transmission system over and above what would otherwise be deemed necessary, simply to ensure system security and adequacy. Alternatively, installing generation locally in an appropriate location may mean that transmission security is no longer a risk, provided nodal pricing risks for all local loads can be covered through market or off market hedge contracts. With either scenario the generation section of the supply chain has increased security showing that there is often more than one potential solution.

Another view of security and risk in the supply chain as put forward by Network Waitaki is that there is no merit in delivering high security levels in only one part of the supply chain if that standard is well beyond any security of supply delivered at the customer connection. Over-investing in any one part of the supply chain can result in wasted investment and overall higher costs.

Transpower plans and operates at n -1 security for transmission to avoid cascade system failure, but network companies can and do have different definitions of security for their individual networks. For example, Orion invests in their network to provide 'interrupted n -1' security to certain groups of customers. There is very little scope currently for a customer to contract their desired level of security at a GXP and not end up paying for n – 1 security. Transpower operates at the higher n-1 security level as it has so many customers resulting in the idea of 'paying for the security you want', or "user pays", being very hard to implement.

There may be a case for further exploring the "weakest link" in relation to Regional security of supply standards. A Regional cost-benefit analysis might reference to the identified weakest link in the overall delivery chain, whereas the national cost-benefit analysis could determine the Regions net contribution (import vs. export) to the total national system.

8 PLANNING FRAMEWORK

This section combines the vulnerabilities of the Canterbury region with respect to security of supply and looks at the solutions that have been proposed.

The following graph from the CMA Report "Will It Take More Blackouts Before We See The Light?" provides an illustration of the projected national supply shortages by 2010-2012. Analysing the regional implications of these findings will be undertaken in Stage 2.

Further evidence of the deteriorating supply situation may be found below. It indicates that current security margins are, and will continue, below the conventionally accepted Minimum Security Margin.

Grid

The following details have been found through a number of channels including; Transpower presentations, the EC's SOO and Transpower's APR.

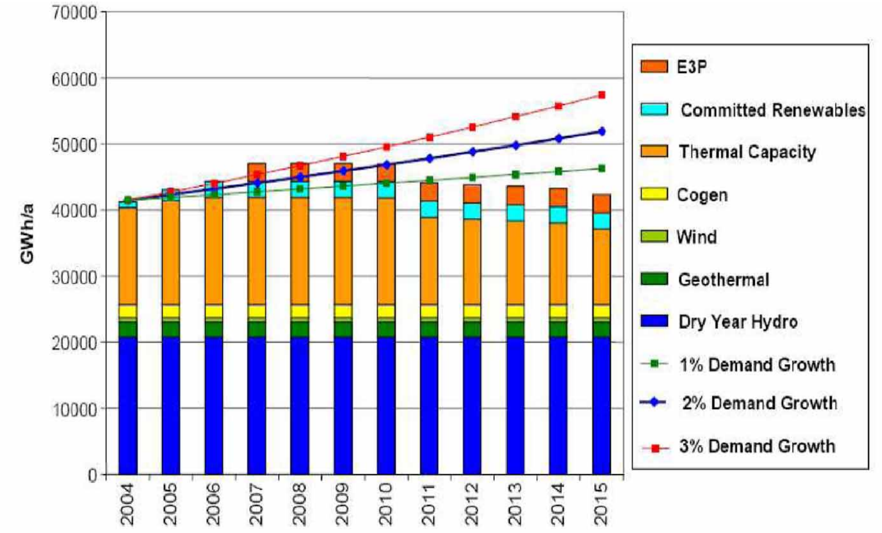

Figure 10: Projected National Supply Shortages by 2010-2012 [Source TBC]

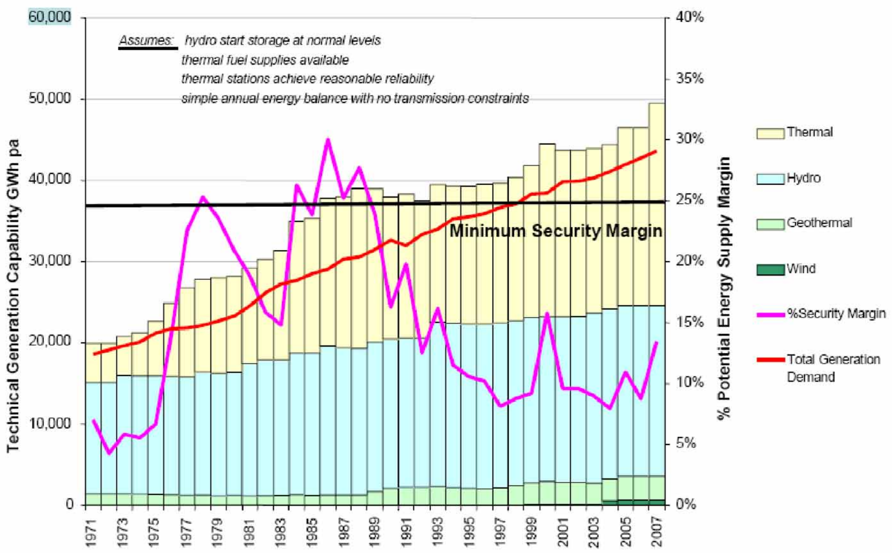

Figure 11: Decreasing Security Margin [Source:TBC]

Networks

The following issues are some of the upgrade options put forward by network companies in the Canterbury region. Anything lower than 66kV has not been detailed here and readers are directed to the individual Asset Management Plans

Incremental vs Large Scale Investment

The market environment that the electricity industry currently operates in creates a situation that favours small incremental investment. This is due to the nature of investment signals such as nodal price and

Vulnerability	Date	Proposed Solutions
Supply to Top of South Island	2006	Transpower has already committed to string the third 220 kV circuit Islington to Kikiwa.
Supply to Christchurch and upper South Island	2008	-Bus the 220 kV Twizel–Islington circuits at Ashburton - Add capacitors at Islington. - Add capacitors at Ashburton. -Construct a new transmission line from the Waitaki area to Islington. - Install a large SVC at Islington. - Install new generation in or north of Christchurch. - Demand-side response. - Modifications to existing assets.
Supplies to Upper South Island region constrained	2012	Supply Options: - Generation north of Christchurch, diesel generators up to 40 MW Demand Options: - Some short term relief by load shifting between GXP's - Demand reduction through load management of up to 73MW - Energy efficiency initiaitives Transmission Options: - Tapping off electricity from the HVDC line near Waipara - Bussing of the 220 kV transmission lines supplying USI at Geraldine (effectively reducing the impact of outage of a line) and shunt reactive compensation - Series compensation of the transmission lines (effectively shortening the length of the lines) *The potential solutions outlined are incremental options to delay significant transmission investment* -Major transmission investment (ie. new transmission line) between Waitaki and Christchurch
Overloading of a 220/66 kV	Prior to	Interconnecting transformer replacement

Table 14: South Island Transmission Vulnerabilities and Proposed Solutions

interconnecting transformer at Bromley	2011	
Overloading of a Kaiapoi supply Transformer	2008	Supply transformer replacement
Overloading of an Ashley supply transformer	2009	Supply transformer replacement
Waipara supply security		Supply transformer replacement
Overloading of a 220/66 kV interconnecting transformer at Islington		Issue can be managed operationally; no investment required at this stage.
Overloading of a Bromley supply transformer		Issue can be managed operationally; no investment required at this stage.
Supply security at Black Point	2006	New grid exit point (GXP) at Black Point
Overloading of a 110 kV Oamaru-Studholme- Waitaki circuit	>2006	Thermal upgrade of the Black Point Tee-Waitaki circuit
Overloading of a Timaru supply transformer	<2010	Add a 110/33 kV, 80 MVA transformer
Exceeding existing limits of an Oamaru supply transformer	2008	Upgrade protection settings for existing transformer
Exceeding existing limits of a 220/110 kV interconnecting transformer at Timaru		Under Investigation
Overloading of a Temuka supply transformer		In discussion with local lines company
Overloading of a Studholme supply transformer		In discussion with local lines company
Overloading of an Ashburton supply transformer		Issue can be managed operationally; no investment required at this stage.
Transmission security at Albury and Tekapo A		Transpower will discuss issue with local lines company
Supply security at Tekapo A		Issue can be managed operationally; no investment required at this stage.
Supply security at Albury		Issue can be managed operationally; future Investment will be customer driven
Supply security at Waitaki		Issue can be managed operationally; no investment required at this stage.
Supply security at Studholme		Issue can be managed operationally; no investment required at this stage.

Table 14: South Island Transmission Vulnerabilities and Proposed Solutions (cont'd)

regulations requiring least cost investment. Anecdotally, investment signals are not present in the market early enough to be able to justify a large scale investment or where investment signals exist, no investment is made. The reasons behind the lack of investment where price and regulatory signals do exist are varied but include, for example:

- A lack of clear longer term market price-risk signals for indigenous vs imported energy resources
- Uncertainties in policy and regulation environments for longer term investors
- A lack of a clear "cost of capital" signal from new investors for regulatory frameworks and decisions supporting incremental solutions.
- Often low probability event, but high impact nature of the market supply pricing risks
- A lack of appropriate mechanisms in place for allocating "causer pays" costs for many

price signals, other than by consumer prices – should this in fact be the appropriate outcome?

- Unwillingness or inability of major energy consumers to acquire longer term supply contracts and thus support new investments
- Average wholesale market prices do not yet support new many investment hurdle costs
- Possibility of “free rider” outcomes.

Incremental Investment Options

The incremental investment process is the one that is encouraged by the current market and regulatory environment. The options for security of supply and long term planning for Canterbury include the preferred investment plan of Transpower as outlined below.

2008

- Bus the 220 kV Twizel–Islington circuits at Ashburton
- Add capacitors at Islington.
- Add capacitors at Ashburton.
- Install a large SVC at Islington.
- Install new generation in or north of Christchurch.
- Demand-side response.
- Modifications to existing assets.

2012

Supply Options:

- Generation north of Christchurch, diesel generators up to 40 MW.

Demand Options:

- Some short term relief by load shifting between GXP’s
- Demand reduction through load management of up to 73MW
- Energy efficiency initiaitives.

Transmission Options:

- Construct a new transmission line from the Waitaki area to Islington.
- Tapping off electricity from the HVDC line near Waipara
- Bussing of the 220 kV transmission lines supplying USI at Geraldine (effectively reducing the impact of outage of a line) and shunt reactive compensation
- Series compensation of the transmission lines (effectively shortening the length of the lines).

In undertaking an incremental investment approach much of the investment savings come through deferred capital expenditure. It is unknown how this value of deferred capital expenditure compares with the nodal risk and security risk caused by the investment’s incremental nature.

Potential Large Scale Investment Options

The large-scale investment options for Christchurch are varied and potentially involve a number of investment combinations. In terms of comparison with the incremental investments above, the following investments could be considered as part of a large-scale investment path:

- Major transmission investment (ie. new transmission line) between Waitaki and Christchurch in the near future (6 years?)
- Installation of major generation north of Christchurch (relocating Whirinaki?, wind generation? gas? coal?)
- Major demand reduction via demand side initiatives (e.g. price signalling, load transfer)
- Investment in peaking plant by networks to reduce reliance on transmission and reduce connection charges.

National vs. Regional Planning

National planning and regional planning often have a very different focus. The focus of national planning is to ensure security of supply for the whole country and to enable the entire system to be operated in such a way as to prevent cascade failure. Preventing cascade failure is reliant on having a system that is both adequate and has n-1 security, these two combining together to give a reliable system. Regional planning ensures security of supply

Location	Issue	Solution	Date	Network Company
Bromley 220kV	220kV bus fault causes an interruption to 150MW. Restoration achievable in 2hrs	Cost/benefit analysis of new bus coupler to be undertaken	To be advised	Orion
Bromley 66kV	Single transformer failure causing cascade trip during high loads (10% of the time) Restoration achievable in 1hr	Short term- Automated load transfer scheme. Long term- Transpower to install new inter-connector capacity at Bromley	2006 To be advised	Orion
Islington 66kV	Not able to supply load for a double transformer failure	New interconnector capacity at Bromley Possible challenge of security standard. Treat transformer failures differently to line failures	To be advised	Orion
Islington 33kV	Not able to supply load for a dual transformer failure	Reduce security gap by increasing 11kV ties. Convert Middleton to 66kV. Possible challenge of security standard. Treat transformer failures differently to line failures	2006	Orion
Papanui 66kV	66kV bus fault causes an interruption to 100MW of load. Restoration achievable in 1hr	Cost/benefit analysis of new bus coupler to be undertaken	To be advised	Orion
Brighton 66kV	Unable to supply 6MW of load during double cable or transformer contingencies	Increase the quantity of 11kV ties between Dallington and Brighton,	2006	Orion
Lancaster 66kV	Loss of 14MW of load for a single	Complete a 66kV loop from Armagh to Dallington Possible challenge of term	2015-2016	Orion

Table 15: Consolidated Network Company Upgrade Plan

	cable failure Restoration achievable in 10min	"immediate" in C1 & C2 of security standard.		
Hororata 66kV	Loss of one of the Islington to Hororata lines during low Coleridge generation will require load shedding at Hororata	Islington to Hororata line upgrade and capacitor installation at Hororata	2006-2007	Orion
Springston 66kV	Not able to fully restore load for a dual line fault	-Security gap reduced by installation of Greendale substation -Installation of Islington to Rolleston East 66kV line, see project 192	2006 2012	Orion
Ashburton 66kV	66 kV GXP will exceed the firm capacity of the alternative supply (33kV??)	Solutions to this have yet to be resolved but are likely to involve the addition of a second 220/66 kV transformer and a second feed from the 66kV GXP	2008	Electricity Ashburton
Ashburton 66KV	Additional security required	-The two 60/100 MVA 220/66 kV transformers working in parallel with a pairing of an existing 50 MVA 220/33 kV unit and the 33/66 kV autotransformer, -Two larger 220/66 kV transformers to replace the 60/100 MVA units, - a third 60/100 MVA transformer, - a geographically separate and new Transpower substation offering an alternative 66 kV GXP	<2015	Electricity Ashburton
Elephant Hill	Security of Supply	A new GXP may be required in the southern region (Elephant Hill) due to irrigation demand and to reduce demand at the Studholme substation	<2015	Alpine Energy

Table 15: Consolidated Network Company Upgrade Plan (continued)

for the current and future loads but should also consider the desired rate of regional growth not just the forecasted growth rate. If it is desired that regional growth increase, the infrastructure to supply energy to facilitate that growth must also be planned and invested for.

National and regional planning have quite different time frames associated with planning. Nationally, planning is undertaken on a 10 to 15 year time frame. From Transpower's 2006 APR:

> *The APR .... to provide a comprehensive 10-year forecast of the issues impacting on the National Grid and Transpower's plans and possible future paths for development.*

Comprehensive regional planning is undertaken on a shorter time frame of between 3- 5 years with tentative planning undertaken out to a 10 year time frame. From the AMP of Orion 2006:

The AMP looks ahead for a period of 10 years commencing 1 April 2005. The main focus of analysis is the first three to five years and for this period most specific projects have been identified. Beyond this period, analysis tends to be more indicative based on long term trends and it is likely that new development project requirements will arise in the latter half of the 10 year planning period that are not currently identified.

National vs. Regional Benefits

Different investment plans result in different distributions of the benefit of the investment. For example, an incremental investment plan benefits Transpower by deferring investment and hence saving them money. This investment plan may still leave Canterbury with high nodal risk and potentially constrained capacity under certain operating conditions. Canterbury has received none of the benefits that Transpower has through the delayed investment.

Conversely, if a stronger grid resulted out of Transpower investing heavily in transmission then Canterbury benefits hugely through increased security, the ability to attract energy intensive industries and lower nodal risk but Transpower is paying the investment cost. Some of this cost is passed onto the network company through connection charges but the immediate sunk capital cost is Transpower's.

National vs. regional benefit issues are highlighted by the suggestion that:

Canterbury region would benefit from 50MW of gas engine peaking plant intended to operate 8hours per week day during peak season. Installed in a location where heat can be utilised (to raise water supply temp, for example, reducing consumer load or providing energy for heat pumps). This would cap energy price by always bidding into market at operating cost and also stop generator gaming.

The issue with this suggestion is that currently the investment by itself is not financially viable but should the peaking plant be installed, Transpower may be saved some necessary investment. If this benefit to Transpower was able to be transferred to the Canterbury region then the peaking plant investment may become viable.

Transferring of benefits does not fit easily within the market environment and regulatory change would be required to the way in which the GIT is implemented before options like this one could be investigated.

9 FUTURE GENERATION OPPORTUNITIES

The National Statement of Opportunities (SOO), produced by the Electricity Commission, modelled a number of future generation scenarios and their respective effects on the generation and transmission balance within a region.

These scenarios incorporated a large number of simulations and analysis, including NPV analysis of suggested projects based on market simulation to obtain nodal prices, and power system analysis to study stability, constraints and interregional flows.

Projected Regional Generation and Demand Balance

The following graphs illustrate the supply and demand projection for the Canterbury and South Canterbury regions between 2005 and 2025 and set the context for the generation scenarios to follow.

These diagrams highlight the fact that Canterbury has significantly more demand than generation currently and under future genera-

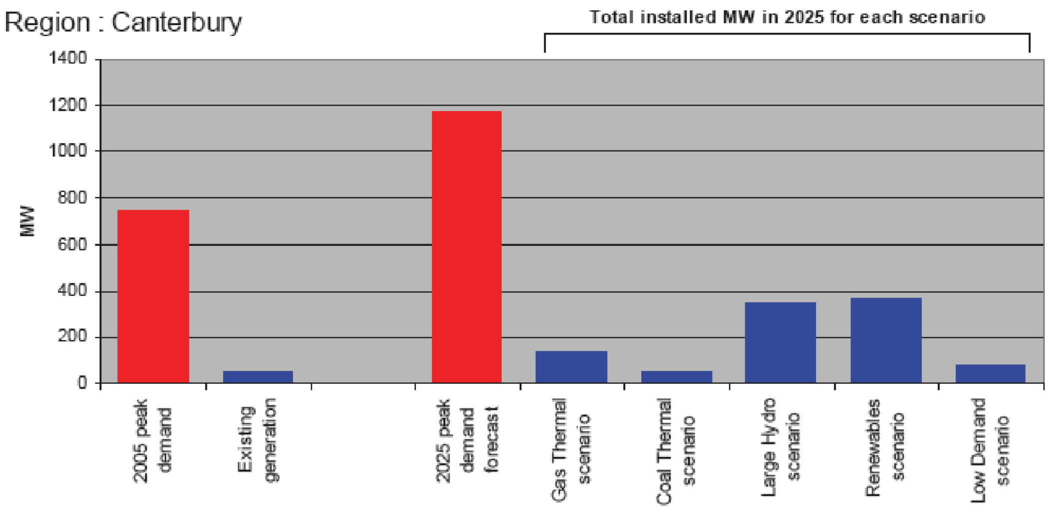

Figure 12: Regional Demand & Supply Balance for the Canterbury Region [EC SOO 2005:140]

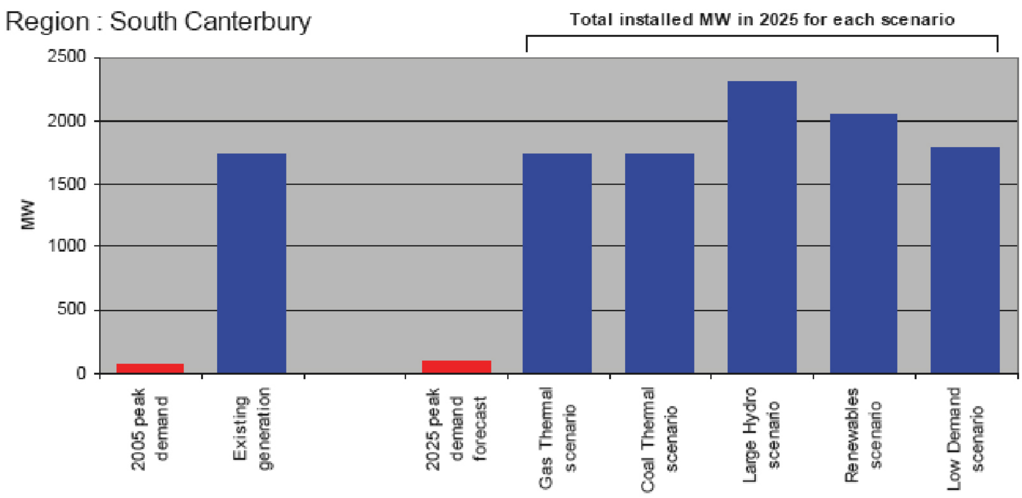

Figure 13: Regional Demand & Supply Balance for the South Canterbury Region [EC SOO 2005:140]

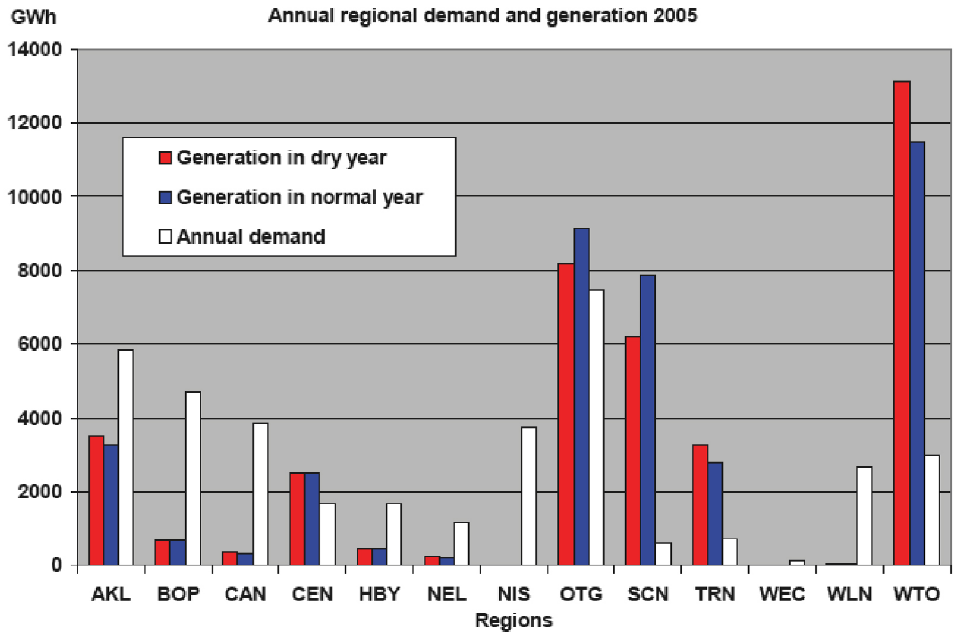

Figure 14: Annual Regional Demand & Generation 2005 – comparison of dry year against normal year [EC SOO 2005:142]

tion and demand scenarios. South Canterbury is the opposite, with significantly more generation than demand now and in the future. Under each generation scenario in 2025, the expected amount of installed generation vs. demand forecast is used.

Under each SOO scenario illustrated above, the growth in regional demand exceeds the growth in firm regional generation capacity, indicating that the timing of future grid upgrade decisions is likely to be a key determinant of supply risk.

These scenarios indicate only renewable (likely non-firm) generation growth in South Canterbury – with significant potential export capacity growth

The suggests that Canterbury (excluding South Canterbury) is one of the few regions in the precarious situation of having significantly more demand that generation, only Wellington, Hawkes Bay and the Bay of Plenty are similar. This difference between generation and demand is a large vulnerability for the system.

The following figures indicate that this unfortunate situation is unlikely to change in the medium to long term either.

This analysis highlights the following:

1. That the extent of reliable new generation in or north of Christchurch is a critical factor in determining the most appropriate augmentation of the South Island transmission network. It is possible that some combination of capacitors at Ashburton and Islington and generation in or north of Christchurch could be sufficient to defer the construction of a major new line.
2. The analysis also indicated that a number of main transmission network South Island interconnecting transformers were likely to be significantly overloaded following any outage of parallel interconnecting transformers. The analysis suggests that both the Islington and Bromley 220/66 kV interconnecting transformers would need to be upgraded at some stage during the planning period.
3. Under most scenarios noted above, Canterbury region grid reserve margins are unlikely to improve significantly over the next ten years. This indicates current operating and pricing risks will remain for the foreseeable future.

South Island Generation Opportunities

Committed Generation

Committed projects include investment in transmission augmentation, generation, and

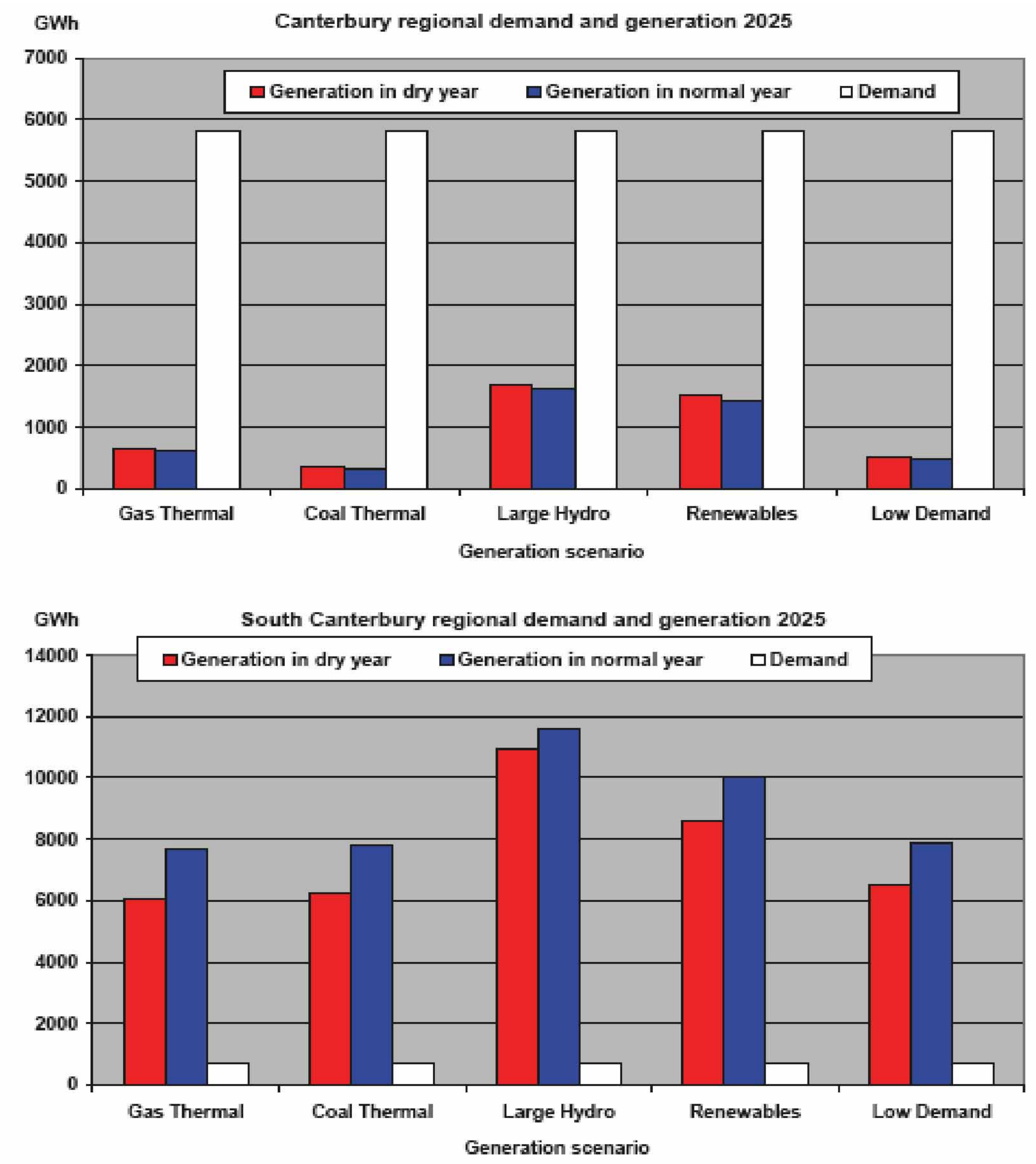

Figure 15: Canterbury and South Canterbury Regional Demand and Generation 2005 [EC SOO 2005:148]

demand-side management. The GIT defines "committed projects" as those, which are reasonably likely to proceed, and where the following are satisfied:

- All necessary resource and construction consents have been obtained;
- Construction has commenced or a firm date set;
- Arrangements for securing the required land are in place;
- Supply and construction contracts have been executed; and
- Financing arrangements are in place.

The only committed generation project identified in the initial national SOO (2005) for the South island was the 16MW "Manapouri Improvements II" hydro project by Meridian scheduled for 2005.

Possible Generation

In addition to the committed project identified previously, a vast array of potential generation projects were identified in the SOO, ranging from 300 MW gas-fired stations to 3 MW wind farms. Many of these are reportedly under active investigation by potential investors, while others are only indicative.

While the table above suggests that a significant number of potential generation opportuni-

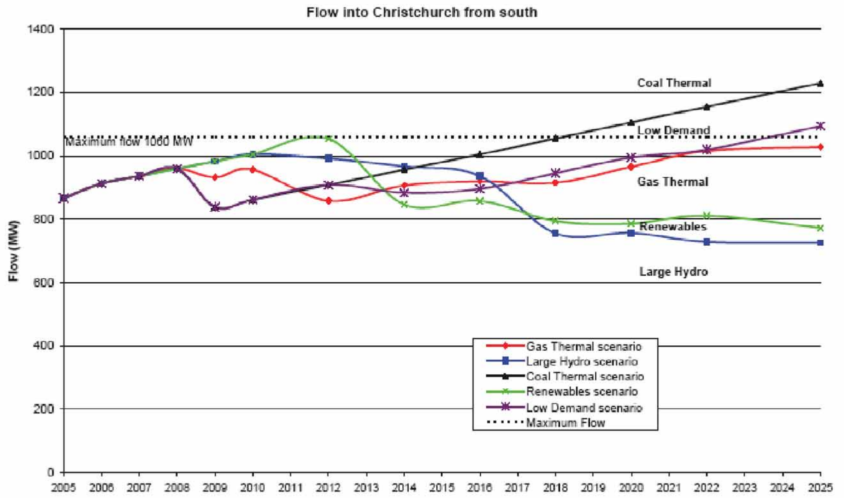

Figure 16: Electricity flows into Christchurch from the south under different generation scenarios [EC SOO 2005:151]

ties, the Study Team has been unable to test the viability or feasibility of these projects, to time constraints. We believe that such information is central to a regional SOO / regional energy plan and intend to rectify this issue in Stage 2 of the study.

Generation Scenarios

Table 17 illustrates the generation scenarios used by the EC in their analysis. While a regional SOO may require slightly different scenarios to be modelled, matching the Canterbury scenarios with the ones used nationally would allow for a direct comparison.

Table 17 summarises the potential new generation under the different scenarios. Once again this is derived from the national SOO. This table of information may be able to suggest particular planning studies for each scenario that the EC has not undertaken e.g. Should scenario x occur, what demand side initiatives would the region like to see implemented and how does this affect the outcome for the region?

NPV Analysis

The NPV Analysis is intended to provide an illustration of the base costs of each of the generation scenarios and assist in the development of a relative cost-benefit assessment of possible investments. Results are provided for 4 of the 5 scenarios modelled.

Implications for Canterbury from the EC SOO

1. A key issue arising from the analysis of the South Island transmission network is the increasing power flows into the upper South Island.
2. Waitaki to Christchurch transmission

   The requirement for new transmission into Christchurch depends upon the power flow into Christchurch and the upper South Island from the south, and the extent to which it is feasible to support voltage in the area with capacitor installations. This is highlighted in Figure 25, which is a graph of peak power flow into Christchurch from the south for each scenario. In the analysis it was assumed that a number of circuits are bussed at Ashburton and that capacitors are installed at Ashburton and Islington. Under these circumstances it appears that the security criterion can be met, with the existing transmission configuration, provided that the peak flow into Christchurch does not exceed 1060 MW.

   When the flow exceeds 1060 MW, further transmission investments have been modelled in order to avoid voltage collapse following an outage of the Islington–Tekapo B 220 kV circuit.

   This maximum flow is exceeded by 2020 in the Coal Thermal scenario and in 2025 in the Low Demand scenario. In the other scenarios the maximum flow of 1060MW is not exceeded during the study period, and in the case of the Renewables and Large

Plant	Location	Type	MW	GW
Banks Peninsula	Canterbury	Wind	100	395
Canterbury Wind Farm	Canterbury	Wind	50	150
Clarence to Waiau	Canterbury	Hydro	70	300
Coal in Chch	Canterbury	Coal	50	130
Dobson	West Coast	Hydro	60	270
Hawea 1	Otago-Southland	Hydro	30	171
Hawea 2	Otago-Southland	Hydro	90	435
Hurunui Lowry Peaks	Canterbury	Hydro	36	160
Invercargill Wind	Otago-Southland	Wind	180	550
Lower Grey River	West Coast	Hydro	210	920
Lower Waiau	Canterbury	Hydro	50	220
Lower Waitaki 1	South Canterbury	Hydro	260	1500
Lower Waitaki 2	South Canterbury	Hydro	260	1500
Manapouri 1	Otago-Southland	Hydro	25	158
Manapouri 2	Otago-Southland	Hydro	16	105
Mid Waiau	Nelson-Marlborough	Hydro	60	270
Nevis River	Otago-Southland	Hydro	45	197
Pahau	Canterbury	Hydro	43	190
Pukaki Canal Intake	South Canterbury	Hydro	44	120
Rough River	West Coast	Hydro	11	49
Seddon Wind Farm	Nelson-Marlborough	Wind	80	250
Southland Lignite 1	West Coast	Coal	380	2650
Southland Lignite 2	West Coast	Coal	380	2650
Stockton Coal	West Coast	Coal	150	985
Taieri Hydro	Otago-Southland	Hydro	40	175
Taieri Mouth Wind Farm	Otago-Southland	Wind	200	615
Te Anau Gates	Otago-Southland	Hydro	65	350
Upper Grey River	West Coast	Hydro	35	153
Upper Waiau	Canterbury	Hydro	56	240
Wairau	Nelson-Marlborough	Hydro	70	415

Table 16: Potential South Island Generation Plant Options [EC SOO]

Plant	Location	Type	MW	Co
Lyttleton	Cant	Diesel	800kVA	Orion
Bromley (consented)	Cant	Diesel	10MW	Orion
Belfast (consented)	Cant	Diesel	10MW	Orion
Portable Generation	SC		3 x 635 kVA	Networks Waitaki

Table 16a: Embedded Generation

Hydro scenarios, the flow at the end of the period is less than the flow at the beginning of the period as a result of the addition of new generation north of Christchurch in those scenarios.

3. Canterbury Regional Growth

Under all future SOO forecasts, the Canterbury transmission area remains a significant importer and South Canterbury a major exporter of electricity. Notable also is that future forecast generation growth in both areas is predominantly non-firm renewable energy, indicating the existing grid supply reliance is likely to remain and that timing of future grid upgrade decisions will be critical to future supply risks.

Scenario	Assumptions
Gas Thermal	Bulk of new generation will be gas fired due to timely & extensive exploration for gas Level of gas field development required for this scenario is consistent with an assumption of 'significant' field development New plant will be commissioned predominantly near load centres or major gas distribution areas
Coal Thermal	Constraints on the development of other generation increases the reliance on coal as a primary fuel for large scale development Fuel sources include SI lignite, expansion of NI coal reserves & West Coast (SI) generation Coal will be barged to Marsden Pt. NZ supply may be augmented by imports New coal technology not assumed but coal gasification technology may also be a future consideration
Large Scale Hydro	The development of a large hydro scheme in the Lower Waitaki The development of hydro power stations at Dobson & Wairau Potential developments in National Parks specifically excluded Competing interests for water able to be accommodated
Renewables	Generation predominantly from wind, hydro and geothermal Presupposes a Resource Management regime that is favourably disposed towards hydro Large scale new technology generation (biomass, tidal) not required till after 2025 scenario boundary
Low Demand	Recasting of Renewables scenario at lower demand levels

Table 17: EC SOO Generation Scenarios and Underlying Assumptions

Scenario	Generation Mix			Total MW	Total GWH
	Coal	Hydro	Wind		
Gas Thermal	200	317		517	
	1115	2614			2744
Coal Thermal	910	41		951	
	6285	263			6548
Large Scale Hydro	1485	460		1945	
	7415	1415			8830
Renewables		983	510	1493	
		4742	1565		6307
Low Demand	150	276	260	686	
	985	1330	800		3115

Table 18: Generation Mix under varying scenarios

	Capital Cost ($m)		Operating Costs ($m)		Total ($m)
Scenario	Generation	Transmission	Variable	Fixed	
Gas Thermal	$2,457	$587	$11,106	$414	$14,564
Coal Thermal	$3,009	$884	$11,979	$569	$16,531
LS Hydro	$5,399	$686	$8,052	$771	$14,908
Renewables	$4,275	$693	$8,326	$612	$13,907

Table 19: NPV Analysis Outcomes [SOO:108]

10 CANTERBURY REGIONAL ENERGY PLANNING

The following 4 elements will be central to any proposed long-term regional energy planning project.

Common Language

Participants in the electricity market face varying degrees of regulation, operate to different strategic horizons and objectives, have diverse risk appetites and measure their performance (and are measured in turn) using different yardsticks.

The purpose of the Common Language Lexicon is to align all these different factors to a standardised and consistent yardstick in order to facilitate communication, and provide a basis for collaboration, between market participants on a regional level.

Table 20 outlines the criteria defining the framework for this Lexicon.

A summary comparison of key Common Language terms used by regional participants may be found in Appendix 2.

Collaboration Protocol

The Collaboration Protocol will set out the rules governing the relationship between the parties. [To be completed in consultation with CRESG Partners]

Regional Statement of Opportunities

The purpose of a Regional SOO will be to identify and prioritise optimal infrastructure investment opportunities that will contribute towards the project's ultimate goal of facilitating the security of energy supply in the Canterbury Region.

The development of a Regional SOO is outside the scope of this stage of the project but a

SPECIFICATION	DELIVERY	PERFORMANCE
Supply Criteria	**Planning Criteria**	**Systems Operation Criteria**
Establish Demand	Location Factors & Constraints	Pricing Regimes
Investment Horizons	Options Analysis	Security of Supply
Growth Projections	Preferred Solutions	
Demand Profiles (load, annual quantities)	Financial & Investment Criteria	***Risk Transfer***
Load Factors	***Completion Risk***	Load Shedding / Rationing
Consumer Category	RMA & Consents	Distributed Generation
Service Levels	***Regulatory Compliance***	Transmission Rights
Reliability	GIT	Energy Contracts
Security Criteria	Connection	- Power Purchase Agreements
VOLL	Environmental	- Financial Instruments
Adequacy	Governance	***System Efficiency***
Power Quality	Operating Rules	Losses
Sufficient Supply		Load Factor
		Interregional Flows
		Nodal Risk
		Operational Coordination
		Demand Management
		Smart Metering
		Load Shifting
		Price Signals
		Energy Efficiency
		Substitution
		Swaps

Table 20: Common Language Framework Criteria

summary of potential opportunities is provided in the following table. These opportunities were identified from a range of publicly available reports, including Transpower's APR, the Electricity Commission Interim Statement of Opportunities March 2005, and the Asset Management Plans of the various distribution companies operating in the Region.

11 QUESTIONS AND DISCUSSION

In the compilation of this report a number of discussion points and unanswered questions arose that directly affect the issues of regional and national planning for security of supply. These points are listed below.

Questions

- *Should there be a regulated standard of security across the electricity system?*

  There is currently no standard for security across the system that is mandated by regulation. The EEA guidelines are good basis for security planning and the ODV produced by Transpower bases it's methodology on similar requirements. Should the adequacy of regulation of security standards be investigated? Would the EEA guidelines provide a suitable standard for regulation? Why or why not?

- *What is an appropriate measure for power quality?*

  Currently measures such as SAIDI, SAIFI,CAIDI and system minutes are used. Suggestions of using VoLL instead or perhaps in conjunction with the traditional measures have been made. VoLL gives a measure of the risk a customer is prepared to accept and so the security of supply they receive should reflect this risk acceptance. With differing values of VoLL used by different entities (Orion = $13/kWh, CAE = $17/kWh, EC = $20/kWh) does this mean that Canterbury will accept more risk from the grid than the national average?

- *Should network companies have more influence on system investment where it directly affects their business?*

  Generation and retail sectors of the electricity industry are national industries, their business can be shifted to mitigate undesirable circumstances such as high nodal risk. Subtransmission is regionally constrained so has no ability to mitigate risks by shifting their business.

- *Does the Grid Investment Test (GIT) adequately consider regional and social or community needs? If not, who should be able to put influence and input into the GIT and what mechanisms could be used to do this?*

- *Should a network company want to pay for security and hence grid investment that Transpower doesn't deem necessary under it's planning criteria, can payment be made so that the desired security level is obtained?*

- *Is it possible to contract for lower security from the grid e.g. n security and have the grid operated in real time to n security at that node?*

- *The end of mandatory supply will occur in 2013. What will happen in the system after this time? How will these customers contract for supply?*

  This date of 2013 fits within the planning time frame of Transpower and the long term forecasts of network companies, yet very little has been mentioned to date on this. Will prices rise? How many customers may be affected? Is everyone just hoping that the law will change?

- *Are there ways to change or augment the current planning rationale to give different types of investments that exhibit these economies of scale a greater chance of success?*

  Incremental investment results in economies of scale being lost. These economies of scale may be cost of capital, size of plant or management of assets. By having an environment that encourages just in time investment these economies are lost resulting in an overall sub-optimal solution.

- *How should the constraint pricing risks be allocated and how will Retailers total regional load risks be covered if local incremental supply solutions are used to manage grid constraints?*

Discussion Points

- The commercial sector needs to be more proactive in finding solutions to their energy solutions. It may be that using VoLL in these situations helps both the industry and network companies come to agreed solutions.

- Incremental investment results in a 'just in time' philosophy that results in delayed investment until future uncertainties are known. This delay itself causes further uncertainty and so could be a self-perpetuating cycle of investment delay. Large-scale investments and the associated economies of scale could be a solution to these delays.
- International experience (including New Zealand re. Auckland 1998 and 2006) has shown that it often takes a major system incident before investment occurs and restores the system to an acceptable operating level.
- It appears that some nodal risk is desired in order to justify planned investments. The issue is that if the risk is too high a market participant could walk away from doing business there but if the nodal risk doesn't exist then investment won't pay for itself. Related to this is that while nodal risk indicates the opportunity for investment, once investment is made the nodal risk drops and economic payback for the investment may not be viable. This again increases uncertainty and delays.
- Regarding DSM, retail prices appear to be too cheap to affect change to customer demand profiles. Without the incentive of large prices to influence knowledge acquisition and understanding, end use energy patterns (particularly residential) are not going to change. Related to increased effectiveness of the demand side of the market.
- Using VoLL as a measure to facilitate security planning has both pros and cons. The pros being that risk acceptance of customer blocks or regions can be known and security planned accordingly but the cons are that in a meshed urban network differentiating between different customers with different risk preferences is very complicated. Where the majority wish for n-1 security and the minority want n security there exists the potential for the n security customers to 'free ride' off the n-1 security paid for by other customers.
- Investment planning is undertaken based on demand peaks, which are growing. The result of this is the reserve margin in the system is getting smaller due to a delay in generation investment. Whatever the reasons for the delay in generation investment this shrinking of the reserve margin affects the ability of the system to cope with unforeseen events. These constraints will then impact on the market producing higher prices and greater uncertainty. Market participants may even prefer this scenario where they can earn a greater return.

12 KEY ISSUES IDENTIFIED

Two key issues for Canterbury have been highlighted in this report. They are summarised below.

- ***The grid in the upper South Island region only has n-1 security because of operational constraints***

  The core grid should have n-1 security under all foreseeable normal operating scenarios, now and in the future.

  Issues/Solutions:

  A potential solution to mitigate this problem involves approximately 30-40MW of embedded generation in Canterbury. This would relieve the constraints on the transmission system throughout the Canterbury, Marlborough and Nelson regions. This solution only works while the amount of embedded generation in the Canterbury region can increase at the same rate as demand growth. If this increase is not possible, the loads in the upper South Island are exposed to constraints and security issues. These constraints will increase the nodal risk making the area potentially unprofitable for retailers. While the embedded generation in Canterbury has solved the immediate transmission constraints it has potentially exposed another load area to increased security constraints and nodal risk.

  Transpower has outlined a series of incremental transmission upgrades to the transmission system as shown in Section 5. These incremental upgrades satisfy their planning criteria for maintaining n-1 security though it may not be the best solution for all market participants. The question has been asked if the Transpower planning criteria is too narrow and doesn't acknowledge the effects of the upgrades on a wider enough regional/market area.

  Associated with the n-1 security of the grid is the load profile of the Canterbury region. The load duration curve shows that large amounts of peak shifting occur to flatten out the usual peaks throughout the day and year. The grid should not rely on this peak shifting in order to provide n-1 security.

- ***The Canterbury region is very heavily reliant on Transmission to supply electricity to the region***

  Canterbury has very little generation of it's own to supply it's load, and is therefore very reliant on the transmission circuits from the lower South Island to supply the electricity needs of the region. This reliance exposes the region to the risks associated with those transmission circuits being owned by another party, Transpower in this case.

  Issues/Solutions:

  There are two main options to deal with this issue. The first is to reduce reliance on transmission by finding opportunities for local generation investment and the second is to retain the reliance on transmission with an enhanced security of supply.

  Local generation exposes the loads north of Canterbury as detailed above due to delayed transmission investment. This is not necessarily an issue for the region itself but it allows for the balance of power in terms of investments to be held in the Canterbury region.

  Retaining reliance on transmission doesn't mitigate the transmission risk but doesn't provide a basis from which the region can make submissions regarding transmission investments and enter negotiations surrounding adequacy and security of supply, i.e. maybe greater security can be negotiated due to the regional reliance on transmission.

- ***The GIT doesn't satisfactorily account for a number of issues including interdependence of transmission and generation, effects on sustainability, social issues, market risks and supply chain risks***

  The GIT has recently been criticised (Reference Auckland report) for ignoring a number of key areas surrounding grid planning. Transmission and generation are mutually interdependent, the decisions regarding investment in each one have been decoupled. The inability of the GIT to consider the interdependence of transmission and generation can result in investments being made that don't fit with climate change policy or the national energy strategy. Other issues that influence investment decisions but are not accounted for in the GIT include market risks such as pricing signals and incremental investment vs. large scale, nodal risks where constraints may force price spikes and supply chain risks as well as social and community issues.

Each of the outlined issues with the GIT affect energy planning in the Canterbury region. Without changes to the way in which the GIT is implemented it is very likely that a sub-optimal investment process will be undertaken.

- ***What does 'Adequacy' mean for Canterbury?***

  A reliable system comes about from the combination of security and adequacy. The question of what is considered adequate for Canterbury has been raised. A survey of the main Transpower and network company substations and GXP supply points has highlighted the lack of true n-1 adequacy and security of supply for the region. It is proposed that a more detailed survey of the supply points be undertaken in Stage 2 of the CRESP project. Further discussions will be needed between the CRESG partners to agree on the approach for this survey and the criteria to be used.

  The overall objective for the region is that the core grid must satisfy true n-1 criteria for adequacy and security while the network companies can each agree on their own criteria for their areas of supply. These criteria could be based on either the deterministic or probabilistic (with VoLL) criteria or both and hopefully be implemented with agreement of the stakeholders in the region.

13 CONCLUSIONS

This report has highlighted two main issues for Canterbury regarding security of electricity supply. The first is that Canterbury is very reliant on transmission to supply energy to the region as there is very little generation in the region itself. The second issue is that the transmission into and out of the region does not have n-1 security under all normal operating conditions.

These two identified issues show the need for urgent investment and planning to be undertaken to increase the security of supply to Canterbury. Transpower has produced an incremental upgrade proposal that defers the need for major investment in the grid until 2012. This deferment, while still enabling reasonable security creates constraints that increase the nodal risk.

This report investigates the issues surrounding regional and national planning and attempts to put forward a method for creating a planning framework. A suggestion that has come out of this work is the need to a regional statement of opportunities document similar to that produced by the Electricity Commission but focussing on a regional rather than national level. This will hopefully facilitate an agreed plan of investment for the region that achieves an optimal outcome.

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APPENDICES

Appendix 1: Potential New Generation in SI by Scenario and Commissioning Dates

Plant	Location	Type	MW	GW	Commissioning Dates by Scenario				
					Gas Thermal	**Coal Thermal**	**LS Hydro**	**Renew -ables**	**Low Demand**
Banks Peninsula	Cant	Wind	100	395			2024		
Canterbury Wind Farm	Cant	Wind	50	150				2009	
Clarence to Waiau	Cant	Hydro	70	300			2017	2017	
Coal in Chch	Cant	Coal	50	130	2009				
Dobson	WC	Hydro	60	270	2017		2012		
Hawea 1	OS	Hydro	30	171	2019				
Hawea 2		Hydro	90	435			2015		
Hurunui Lowry Peaks	Cant	Hydro	36	160	2015		2015	2015	2015
Invercargill Wind	OS	Wind	180	550			2008	2013	2013
Lower Grey River	WC	Hydro	210	920			2018	2013	
Lower Waiau	Cant	Hydro	50	220			2020	2020	
Lower Waitaki 1	SC	Hydro	260	1500			2009	2022	
Lower Waitaki 2	SC	Hydro	260	1500			2014		
Manapouri 1	OS	Hydro	25	158	2004	2004	2004	2004	2004
Manapouri 2	OS	Hydro	16	105	2005	2005	2005	2005	2005

Mid Waiau	OS	Hydro	60	270				2024	
Nevis River	OS	Hydro	45	197	2015			2021	2021
Pahau	Cant	Hydro	43	190			2015		
Pukaki Canal Intake	SC	Hydro	44	120			2020	2020	2020
Rough River	WC	Hydro	11	49			2024	2019	
Seddon Wind Farm	NM	Wind	80	250			2021	2021	2021
Southland Lignite 1	WS	Coal	380	2650		2012			
Southland Lignite 2	WS	Coal	380	2650		2021			
Stockton Coal	WC	Coal	150	985	2011	2009			2009
Taieri Hydro	OS	Hydro	40	175			2015		2020
Taieri Mouth Wind Farm	OS	Wind	200	615			2024	2014	
Te Anau Gates	OS	Hydro	65	350			2014	2019	
Upper Grey River	WS	Hydro	35	153	2023		2023	2018	
Upper Waiau	Cant	Hydro	56	240				2023	
Wairau	N/M	Hydro	70	415	2024		2014		2014
Total Potential New Generation by Scenario (MW)					**517**	**951**	**1945**	**1493**	**686**

Appendix 2: Common Language

Central to the proposed common planning framework will be the standardisation and harmonisation of key concepts.

Outlined below is a comparison of the key concepts and criteria used by different regional electricity stakeholders.

The authors anticipate Stage 2 of this project will focus on determining and developing appropriate criteria for non-electricity industry stakeholders, e.g. territorial authorities, business groups (i.e. CECC), etc.

SUPPLY CRITERIA					
	EC	**EEA**	**Meridian**	**Transpower**	**Orion**
Investment Horizon	20 Years (SOO)		20 Years	10 Years (APR)	10 years (with focus on the next 3-5) - AMP
Growth Predictions	Historical data on drivers for electricity demand. The drivers used are: -population -GDP - number of households - temperature - electricity price - correction for shortage years.		Based on demand forecast from the SOO?	Based on demand forecast from the SOO and converts to regions using regional population data	Historical Trends and known information about expected new load growth
Demand Profiles (max, min, mid)	Confidence Intervals 90% confidence interval between the low and high forecast values		As for EC	As for EC	-With and without CAP -Cold Snap peak -30 Year history projection
Load Factor					Ratio of peak to average demand
Consumer Category	New Category split at 150MW	Class of Supply based on Group Peak Demand (GPD) in MW. Classes: up to 0.5, 1.5, 12, 60, 200, (300) and 600 MW			Class of Consumers based on loads and types in SSS. Up to 1, 4, 15, 40, 60 and 200 MW

Security Criteria		*Security of Supply* defined as "the inherent ability of a network to meet the customer demand for energy delivery without interruption" *Reliability of Supply*, (also called *Adequacy*) defined for the purpose of the Guidelines as "the actual performance of the network in terms of the amount of interruption actually experienced by the customer"		The main interconnected transmission system shall be designed to maintain N-1 security criterion, meaning that the system is in a secure state with all transmission facilities in service and in a satisfactory state under credible contingent events. Specifically, for major load centres that are dependent on local generation for supply security Transpower plans to an n-g-1 reliability level. That is the system remains in a satisfactory state following a forced outage of: any transmission component and an outage of the single largest generator.	n-1 and/or interrupted n-1 and n-2
VOLL	$20/kWh or $20000/MWh	$2 - 5/kWh (NZ pre 1999) A$5/kWh (Victoria 1999) A$20/kWh (Victoria recent)		$20/kWh or $20000/MWh	$13.72/kWh + $6 /kW VOI
Adequacy		The actual performance of the network in terms of the amount of interruption actually experienced by the customer		The ability of the electric systems to supply aggregate electrical demand and energy requirements of their customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements	
Power Quality					
Harmonics					IEC and Join Australia/NZ standards
Voltage				10% violation on 220kV and 100kV grid	230 ± 6%

Frequency				49.8 - 50.2 Hz	
System Interruption				Interrupted supply in system minutes	CAIDI SAIFI SAIDI
Sufficient Supply	*Ensuring electricity supply continues to meet NZ's growing needs *Ensuring electricity is transported to demand location *Eliminating waste throughout the electricity system				

PLANNING CRITERIA					
	EC	**EEA**	**Meridian**	**Transpower**	**Orion**
Location Factors and Constraints			*System Studies*Nodal Risk	*System Studies*Simulation	Load Growth drives system reinforcements
Options Analysis	Options are studied through the GIT	Optimise network service levels against the cost of demand not served. The function cost of supply plus cost of demand not served during supply interruptions" should be minimised	*LRMC * Environmental *Climate Change Policy	*Scenario Analysis *Request for Information *Request for alternative proposals	Cost analysis
Preferred Solutions	Through the GIT		Business Decision???	Business Decision???	Business Decision???
Financial and Investment Criteria	*Efficiency and least cost *NPV		Profit	Least cost	Economic Efficiency
Completion Risk			*Land Access *Resource Consents	*GIT failure *Regulatory inertia *Resource Consents *Land Access	*Monetary constraints * technical/contractor constraints *Resource Consent
Regulatory Compliance			EGR	*Transmission investment proposals must pass the GIT before they can be built *EGR	EGR

GIT	*Promoting economic efficiency (including energy efficiency) in transmission and the wholesale market; * As far as practicable reflecting the interests of end use customers in ensuring a reliable transmission system having regard to the cost to end use customers; * Reflect a reasonable economic assessment of the balance between different levels of reliability and the expected value of energy at risk; * Enabling selection of transmission upgrade options that maximise the total net benefits to those who produce, distribute and consume electricity after taking into account transmission alternatives; * Promoting certainty for investment in transmission, generation and transmission alternatives and investment contracts; and * Facilitating outcomes acceptable to Transpower and designated

	transmission customers.
Connection	
Environmental	Ensuring the commission and the industry play their parts in creating a sustainable future in terms of Government environmental and climate change goals
Governance	
Operating Rules	

SYSTEM OPERATIONS CRITERIA					
	EC	**EEA**	**Meridian**	**Transpower**	**Orion**
Pricing Regimes	Efficient Pricing		*Generator =Wholesale Spot Price *Retailer = unit charges and line rental	Postage Stamp Tariff	Line Charges
Security of Supply	*Ensuring the electricity system operates effectively and efficiently in real-time, with a high level of reliability *Ensuring system ability to deal with changes in generation and use patterns, esp. intermittent generation	The inherent ability of a network to meet the customer demand for energy delivery without interruption		The ability of the electric systems to withstand sudden disturbances such as electric short circuits or unanticipated loss of system elements.	n-1 and/or interrupted n-1 and n-2
Risk Transfer					
Load Shedding/Rationing				AUFLS Automatic Under-Frequency Load Shedding	*Peak Load shifting *Ripple Control
Transmission Rights	A financial risk management product that protects against price risks arising from transmission losses and constraints				
Energy Contracts					
Distributed/Embedded Generation	Generation that is connected to a local network rather than to the national grid.				
System Efficiency					

Losses					Losses occur through heating of lines, cables and transformers. Electrical losses are natural phenomena that cannot be avoided completely and result in retailers having to purchase more energy than is delivered to their customers
Load Factor					Average load that passes through a network divided by the maximum load experienced in a given year.
Interregional Flows					
Nodal Risk			Risk associated with transmission constraints on nodal prices		
Operational Coordination			With both national and regional operator. Coordination regarding HVDC transmission, submission of generation offer to the SO and submission of load bids to the SO	*National: SPD market coordination and Security of supply	Regional operating maintains security, manages outages etc

Demand Management	To determine the optimal load management infrastructure for New Zealand in order to achieve the following benefits from the removal of barriers to investment in existing and new technology: * Greater demand side involvement in the electricity market; * Deferral of investment in distribution, transmission and generation; * Cost reductions from improved market efficiency; and * Innovation in retail products leading to consumer choice and increased competition.				*Peak Load shifting *Ripple Control
Smart Metering			*Time of Use pricing *Real time pricing????		
Load Shifting/ Swaps					*Peak Load shifting *Ripple Control
Price Signalling			*Generator = Spot Price		Time of Use rates
Energy Efficiency	The Commission seeks to identify ways for electricity efficiency to contribute cost-effectively to the government's electricity objectives, and estimate the level of investment required to meet that potential.				
Substitution					