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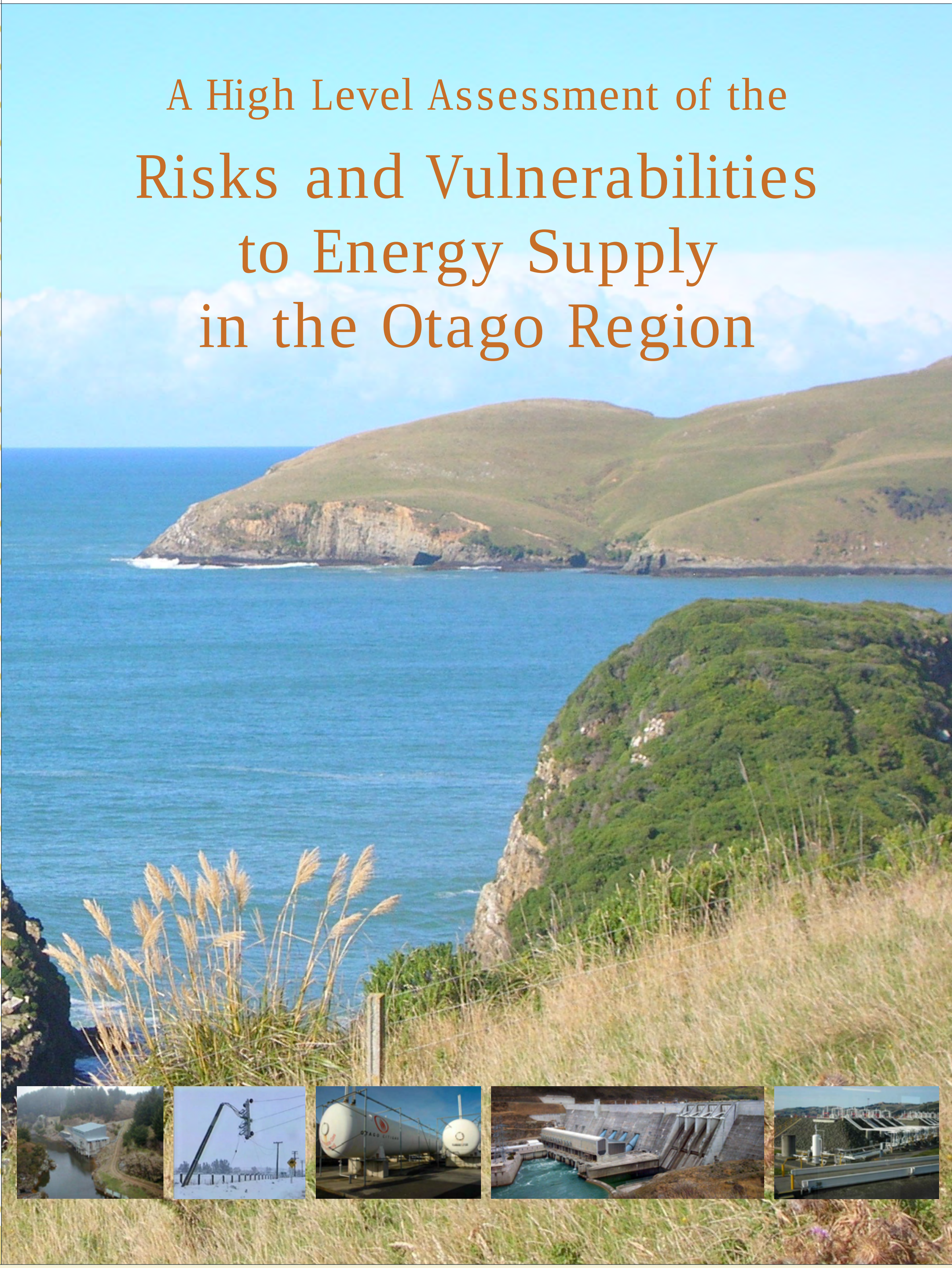
A High Level Assessment of the Risks and Vulnerabilities to Energy Supply in the Otago Region



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25 August 2006

CONFIDENTIAL INFORMATION

Please note that this draft document contains confidential information provided to the Otago Regional Council solely for the purpose of providing a high-level assessment of the risks and vulnerabilities to energy supply in Otago. The information in the document is not intended to be, nor should it be, used otherwise, nor should it be disclosed to other parties at this time.

Approved by:

RJ (George) Hooper

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EXECUTIVE SUMMARY

A secure and reliable energy supply has become ubiquitous to our daily life. At the same time, New Zealand communities are using increasing amounts of energy and are becoming ever more reliant on the delivery of high-quality energy services. Climate change issues are also changing attitudes towards the continued use of fossil fuels, and local communities are beginning to ask real questions about future options. Energy, and securing a reliable and affordable supply, has thus become both a national and a regional issue.

This study takes a first look at the vulnerabilities that characterise the Otago regional energy system. In doing so, the various supply chain components that make up the total system are described and the likely impacts of supply disruption explored so as to provide a better understanding of the risk factors affecting service delivery. With greater responsibilities being devolved to local government and territorial authorities for planning for our critical infrastructure, particular emphasis has been given to building a picture of the ways in which a secure energy supply underpins economic activity within the region, and the region's vulnerabilities to constraints or disruption.

As might be expected, in the absence of any form of integrated planning and coherent policy, Otago is exposed to a range of risk factors arising from a lack of coordination at the regional level in providing for changing load patterns and demographic shifts, as well as capacity constraints within its critical supply chains. These constraints are likely to have a material effect on economic development in the region and leave rural communities, in particular, vulnerable to ongoing disruption from weather-related or human-induced loss. The most recent disruption from snow storms in parts of Otago and South Canterbury are timely reminders of the fragility of some parts of the regional energy supply system.

Beyond this, the report highlights the potential long-term vulnerability of the region to world oil prices and the vagaries of the global energy market. Opportunities abound for increased regional energy supply from distributed energy investment and remote area power generation. These will help towards mitigating such risks, yet investment in the region is lagging other regions in New Zealand. Properly addressed and sensibly progressed, these resources have the potential to deliver considerable economic benefit and energy security to the region.

All of these options need further, more detailed investigation and assessment so as to provide a road map for determining future energy pathways for the region. It is hoped that the report will assist in stimulating further discussion and provide a framework for collaborative action on the priority areas identified. Much needs to be done to deliver an appropriate strategic context for action. Regional initiatives/actions need to give support to energy infrastructure investment and programmes that will deliver to the region (and to its communities) reliable and affordable energy services. The Otago Regional Council has a key role to play in facilitating this process.

CONTENTS

1 BACKGROUND

The changes in the composition of New Zealand's primary energy supply associated with the depletion of the Maui gas field and increased demand is heralding a new era in the New Zealand energy market. We now know that in many parts of New Zealand the national electrical supply system is operating, at times, near to peak supply capacity. In addition, in the thermal fuels market there are potential constraints on natural gas supply as well as looming constraints on imported energy products, in particular liquid fuels. New Zealand faces an uncertain energy future, without any more the luxury of a surplus supply and cheap energy.

The other major uncertainty that New Zealand will face, along with the rest of the world, will be the effects of anthropogenic global warming. Although not covered in this report, it is noted that the mitigation of this particular uncertainty is strongly linked to the methods of energy supply.

Whilst there is some new investment taking place and alternative supply options are receiving public attention, not enough has been done in the recent past to invest in maintenance and expansion of our energy supply system. In this increasingly volatile market environment and with real constraints developing in some areas, concerns over reliable and secure energy supply are becoming more prevalent at both the national and regional levels.

The recent electricity supply blackouts in North America and various European countries, plus the threats to New Zealand of electricity supply disruption, gives emphasis to the importance to society of a secure supply of electrical energy. The most recent snow storms in parts of Otago and South Canterbury are timely reminders of how ubiquitous electricity supply is to our daily life.

The Otago region consists of four District Councils and one City Council. Individually these authorities have limited scope to materially affect supply options but their planning and infrastructure investment combines to determine specific demand outcomes and potential supply bottlenecks for the region as a whole. In such circumstances the Regional Council has a leading role to play to ensure that an adequate and continuous supply of energy can be provided at a reasonable cost. The implications of not doing so are potentially severe from both an economic and environmental perspective.

There is limited information available on energy use patterns within the region and the dependencies that ensue. What we do know is that despite significant local resources, all sectors of the community are strongly dependent on electricity for household energy use and liquid fuels for transportation. While some electricity is generated in the Otago region, a large percentage of the thermal energy consumed comes from outside the region. Oil products for transportation and agricultural activity are a critical lifeline for the region. Any threat of disruption to either the electricity grid or the supply of liquid fuels will have a major effect on the communities and their economic resilience. Domestic space heating is an important concern with its effects on health, comfort and air quality in many areas.

In order to better understand the vulnerability of the region to disruption of its energy services it is necessary to look at the issue from a total system perspective and to understand the interrelationships between the individual supply chains that make up the total system. In the Otago region the important supply chains present are:

- Electricity
- Coal
- Wood

- LPG
- Transport fuels

This report takes a first look at the delivery of these services, and their contribution to the Otago energy system. Information is given on the current supply situation and comment provided on the potential contributions for the future.

A majority of the information presented here is based on interviews with industry professionals engaged in the supply chains or from the public domain.

From this commentary vulnerabilities have been highlighted and potential risks to supply exposed. In addition, the interrelations between the supply chains are investigated, particularly where these may cause interruption of supply. With the resources available to the study it has not been possible to quantify the likely risk outcomes in a formal way. Instead, our aim has been to inform and advise on future regional action to mitigate identified vulnerabilities.

2 STUDY OUTLINE

This study, commissioned by the Otago Regional Council (ORC), is intended to provide a high-level assessment of impacts due to energy supply constraints or any disruption of energy services in Otago.

The primary motivation for this work is the lack of information on the energy supply chains servicing the regions and the need to better understand the region's dependence on its energy supply for both economic growth and community resilience to weather and other disruptive events.

As such, this report provides a starting point for an updateable regional energy information document. The report examines the current energy situation in the region and discusses the risk factors likely to influence future supply pathways. Vulnerabilities are characterised and their risks identified and prioritised for future action. In bringing this work together, the study covers:

1. An overview from publicly available information of the current energy situation including:
    a. Regional demographic, political and geographic details;
    b. Energy usage patterns;
    c. Major energy users;
    d. Available primary energy sources (local and external); and,
    e. Supply chains.
2. A profile of the energy transmission and distribution infrastructure; including discussion on regional energy pricings and the likely effects of projected future energy prices on energy usage and future fuel supply options. This assessment takes into account the uniqueness of the Otago region in terms of its current energy use patterns, potential for fuels substitution and other intervention options.

    Consultation with the incumbent lines companies, energy suppliers, major users, relevant resource owners, and other agencies was also sought to provide a better understanding of the major factors likely to influence future decision-making.

    The issues canvassed in these discussions included:

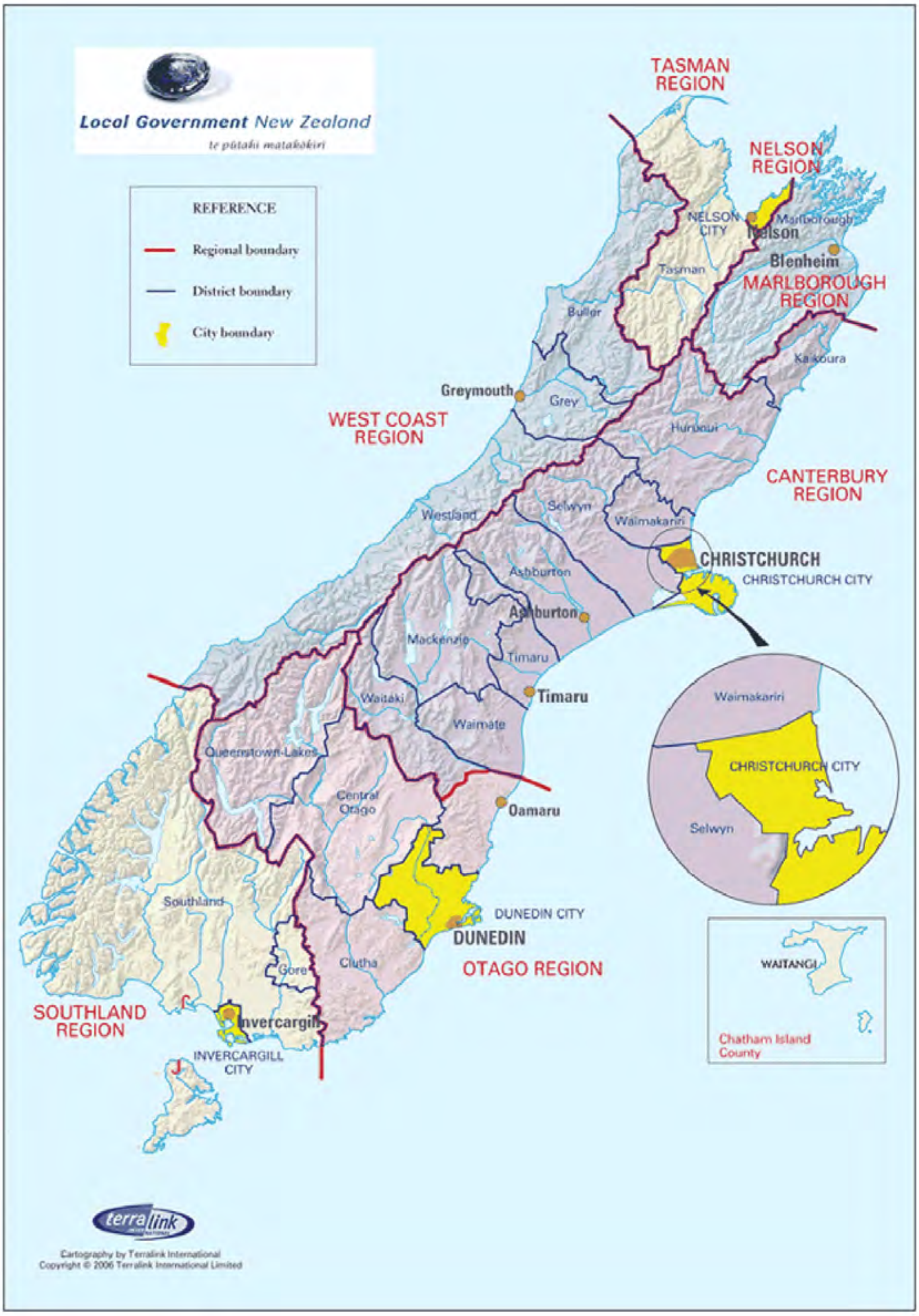
    - Specific locational issues, such as environmental issues.
    - Specific user issues such as service standards.
    - Specific network issues with regard to constraints, security, etc.
    - Specific economic issues such as pricing.
3. A summary of current relevant legislation and regulations affecting utilisation of energy resources within the region. Particular attention has been given to clean air legislation and the influence this will have on home heating and industrial energy use.
4. An overview of non-conventional supply options including distributed energy and demand side options to enhance local supply, including the potential for the development of remote area power systems. These alternatives are examined as a benchmark comparison to conventional investments in energy conservation and network reinforcement.
5. A survey of major electricity users assessing the cost to consumers of non-supply or Value of Lost Load, VoLL. This model was developed for the Electricity Commission to apply to its assessment of the economic value of grid investment in reliability measures. It has been adapted to Otago by substituting the reliabilities of the local distribution networks and incorporating cost data based on the survey findings.

Ultimately, infrastructure assurance is about sharing of information and resources, avoiding duplication of effort and working collaboratively around multiple objectives to secure reliable delivery and service performance. This assessment has been structured so as to provide a framework for further discussion and cooperation amongst the various participant groups, and to stimulate the active involvement of the local government sector in facilitating future solutions.

We hope that the report will assist Council to identify critical assets and supply chain components, and develop policy aligned with related critical infrastructure investments so as to improve regional resilience to future major disruptive events.

3 REGIONAL DESCRIPTION

The Otago region consists of five local government districts: Queenstown-Lakes District, Central Otago District, Clutha District, Dunedin City and part of the Waitaki District (see figure below).



Territorial boundaries for the South Island of New Zealand

3.1 DEMOGRAPHICS

The following information has been gathered from the 2001 census of populations and dwellings. Information from the 2005 census was not available to the study team.

The median income of people in the Otago Region is $15,700 compared to $18,500 for all of New Zealand.

The unemployment rate was 6.6% compared to the national average of 7.5%.

There were 46,224 families in Otago and 69,477 households in the region.

The average household size was 2.5 people compared to the national average of 2.7. 88.4% of households had access to a motor vehicle compared to the national average of 89.9%.

	Otago Region	New Zealand
Males	88266	1823007
Females	93273	1914273
Total	181539	3737277
Change since 1996	-3543	118974
% change since 1996	-1.9	3.2

Age Range	Otago Region		New Zealand
0-14	34492	19.0%	22.7%
15-64	121631	67.0%	40.1%
65+	25415	14.0%	32.2%
Ethnic Group	**Otago Region**		**New Zealand**
European	170102	93.7%	80.1%
Maori	10892	6.0%	14.7%
Pacific Peoples	2723	1.5%	6.5%
Asian	5991	3.3%	6.6%
Other	908	0.5%	0.7%

Income Range	Otago Region		New Zealand
$100001 or more		1.6%	2.4%
$70001 – 100000		1.7%	2.7%
$50001 – 70000		4.7%	6.4%
$40001 – 50000		5.6%	7.1%
$30001 - 40000		11.0%	12.1%
$20001 – 30000		17.0%	16.5%
$10001 – 20000		26.9%	24.9%
1 – 10000		27.4%	22.5%
Nil		3.7%	4.7%
Loss		0.5%	0.7%

Family Size	Otago Region		New Zealand
Couples with children	18351	39.7%	42.1%
Couples without	20708	44.8%	39.0%
Single Parent	7165	15.5%	18.9%

3.2 ECONOMICS

Otago, the second-most populous province in the South Island, makes an important contribution to the New Zealand economy. Ten businesses based in the region were listed among the top 200 businesses of 1997 (by annual turnover). These businesses showed considerable variety, from those producing agricultural or mineral products to food manufacturing. The regional economy is dominated by agriculture, though tourism is extremely important in the region, especially in the Queenstown-Lakes District.

At June 1997 there were 10,840 businesses in Otago, second only to Canterbury in the South Island (with 28,860) and more than double that of the next largest region, Southland. The more rural nature of the economy is revealed in the slightly higher than average percentage of businesses engaged in agriculture, forestry or fishing (5.9 percent compared with the New Zealand average of 4.4 percent). The higher proportion of businesses engaged in health and community services (5.1 percent compared with 4.3 percent nationally) reflects the importance of this industry in the region. The proportion of businesses engaged in cultural and recreational services was the highest in any region, and the proportion of businesses engaged in providing food and accommodation was above the national average. These businesses are both related to the important tourism industry.

High technology industries are also developing in Dunedin, particularly in the information technology, biotechnology and engineering fields. These areas are knowledge intensive, require less resources and are not location dependant. This is a natural progression of the importance of education and expertise in the region, which is now offering commercial opportunities in the global economy.

3.3 ENERGY RESOURCES

WOOD

Wood is a common form of stored energy in Otago, used mainly for residential space heating. Because of high transport costs wood is usually sourced locally with individual households maintaining their own supply stock for various time periods of between a few months and a year or more. This buffer makes wood a good back up fuel that cannot easily be disrupted by external events.

Wood as an Energy Source

Depending on the species, oven dry wood (<5% moisture) has a net calorific value of around 19.2 MJ/kg for softwoods and 18.2 MJ/kg for hardwoods, or 18.7MJ/kg averaged for both. Air-dry wood (25% moisture) delivers and average net calorific value of 14.5MJ/kg. Green (55% moisture) wood delivers around 9MJ/kg.

Inefficiencies in combustion mean that the net energy available is quite a lot less than that indicated by the calorific value. An open fire achieves between 5% and 15% efficiency, a pot belly maybe 35%, and modern enclosed solid fuel burners between 50%-80% when used correctly (Somewhat lower efficiencies were indicated by the BRANZ Housing Energy End Use Project (HEEP) which found 13% for an open fire and 54% for enclosed burners). Pellet burners using controlled forced air combustion can reach over 90% efficiency.

As will be discussed later in this report the major issue surrounding the use of wood in domestic burners are particulate emissions to the atmosphere, especially in areas subject to high pollution levels.

Resource

Most New Zealand firewood is derived from exotic forests. As of April 2005 there were 129,350 ha of exotic forest in Otago, equivalent to approximately 21,170 million cubic meters of standing volume. The area-weighted average age of the resource was 13 years. Radiata pine on average is 27.9 years of age when harvested. Sixty-three percent of the standing volume is in the Clutha District, with 21% in Dunedin City, 10% in Waitaki, but with Central and Queenstown holding only 5% and 1%, respectively.

The harvested wood is either exported as whole logs or sent to the wood-processing sector. In 2003 1,553,000 m^3 was harvested and sent for processing in Otago / Southland. Recovered forest residues are typically chipped for export or processing. Some smaller forestry owners may recover firewood for its potentially higher margin. With 7% average non-harvested residues (large branches and unmerchantable stems)[1], 2003 could have provided for as much as 108,710 cubic meters for firewood.

The wood-processing sector consists of three major sub-sectors, the saw milling, pulp and paper and panel producers. There are 16 sawmills in Otago/Southland, each producing more than 5000 cubic metres of sawn timber per annum. Two panel board mills are located in Southland: Rayonier New Zealand MDF in Mataura and Southland Veneers in Invercargill.

Nationwide, the wood processing industry is using increasing amounts of waste wood to provide process heat. As of 2003, 37 PJ out of the total 69 PJ consumed for process heat by the industry was biomass derived. However, driving this trend has been the cost of disposal and waste minimisation strategies within the sector. Basically modern processing plants are moving towards closed-loop operation resulting in lesser amounts of timber processing waste available for firewood.

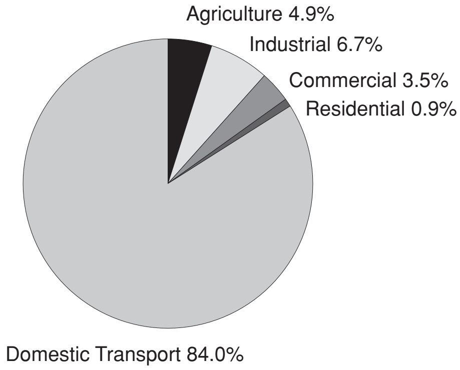
With fossil fuel energy costs rising, and timber harvests projected to increase by 30% in the next 15 years, a dedicated wood harvesting industry could potentially compete with existing fuel wood merchants who basically recover wood from farmlots and other commercial sources. However the costs of forest recovery systems are such that, unless there are other drivers, forest residue recovery is more likely to be targeted to industrial fuel applications, rather than firewood.

Overall, there does not seem to be either a supply or security issue with firewood in Otago. Future tightening of regulations for air quality may well force down the use of firewood leaving an even higher surplus of wood for the region. It is likely that firewood will become a reserve heating fuel of choice when the supply of other (mainly fossil) fuels becomes either too costly or not available. Outages in the electricity supply grid will in all likelihood accelerate movement to wood fuels.

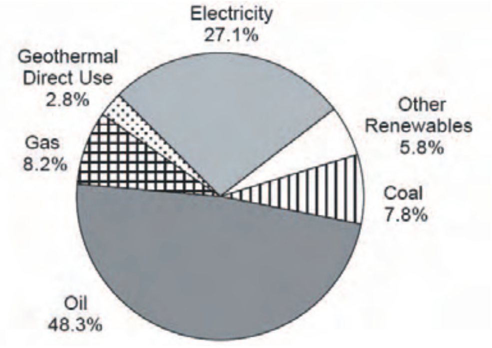
PETROLEUM

Current Supply

Current petroleum supply and end-use statistics are as summarised in the figures below.



Oil use by sectors (exc. International transport)
(NZ Energy Data File, 2005)



Total consumer energy by fuel 2004
(NZ Energy Data File, 2005)

New Zealand imports over 80 percent of its petroleum requirements and is thus very vulnerable to increases in the international oil price. Oil consumption in the year ended March 2005 was 250 petajoules – a 5% increase on the March 2003 figure. Domestic transport (84%) dominates petroleum use and is a key contributor to this demand growth.

The discovery of the onshore Kapuni gas field (1959), the huge offshore Maui gas field (1969) and the McKee oilfield (1979) confirmed the hydrocarbon potential of the Taranaki basin. These, and other more recent discoveries, allowed New Zealand to be self-sufficient in natural gas from the 1970s and to attain some domestic oil supply over the 1980s and 1990s. The depletion of the Maui gas field (which also produced condensate) has seen both oil and gas production drop drastically over the early 2000s.

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[7] Estimated from Table BMW2, row 2003, in Availabilities and Costs of Renewable Sources of Energy for Generating Electricity and Heat, Ministry of Economic Development (East Harbour Management Services), June 2005, p 115

Up to the year ending December 2004 a cumulative total of some 6,258 bcf (billion cubic feet) of gas and 444 million barrels of oil had been discovered in New Zealand. In addition, a further 238 bcf of gas and 27 million barrels of oil were identified in fields that were still undergoing appraisal. Almost all of this has been found in the Taranaki basin.

The Maui field, which was among the largest gas fields in the world when found in 1969, has dominated the New Zealand gas market until recently. With original reserves measured at 3,439 bcf (billion cubic feet) of gas and 219 million barrels of oil. By January 2005, the field's oil reserves were estimated to be 92% depleted, and gas reserves were 91% depleted. These reserves may be exhausted as early as 2007.

Replacement of gas reserves is critical to managing the transition from Maui gas. Recent announced developments include the Pohokura and Kupe fields, which together provide over 500 bcf natural gas. In addition to Taranaki, however, there are other prospective zones which are receiving increasing attention, particular the Canterbury and the Great South basins. New Zealand has amply demonstrated the capacity for significant discoveries in the past, and with increasing oil and gas prices New Zealand can expect to see heightened exploration interest over the next decade. CAE has previously assessed future gas supply opportunities and sees the potential for considerable additions to NZ's gas reserves.

Four companies dominate petroleum distribution and retailing: BP, Mobil, Shell and Caltex. These companies have interests in the Marsden Point oil refinery and between them they own most bulk-storage facilities and many of the country's petrol stations.

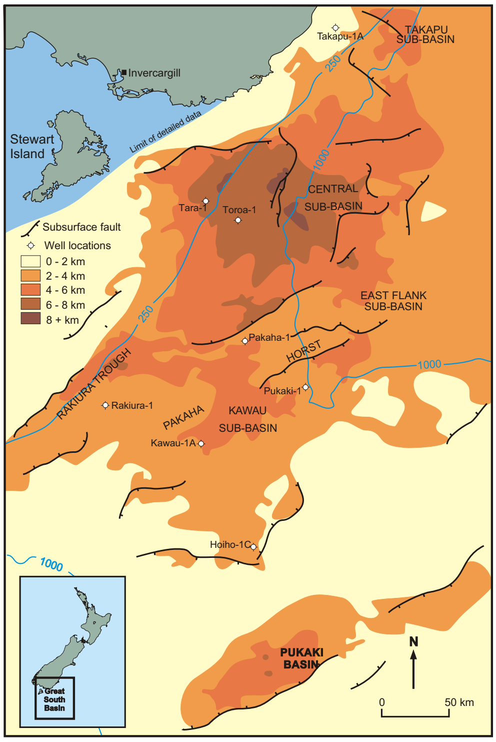
New Zealand's only oil refinery is at Marsden Point, Whangarei, and it is designed to supply the majority of New Zealand's demand. The refinery operates on low-grade (and relatively low-cost) Middle East crude oil. About 94% of the hydrocarbons it processes are imported, with the remainder sourced from New Zealand fields. New Zealand's higher-quality oil and condensate (light oil) are sold at higher prices on the international market – much of it to Australia.

The Marsden Point refinery produces a full range of petroleum products, including petrol, diesel, jet fuel and fuel oil. Its hydro cracker configuration offers greater processing flexibility than many other refineries in the region and is it is designed to meet the specific blend slates for the New Zealand market.

From an Otago perspective both the Great South and Canterbury basins have important implications as future prospective oil and gas resource for the region.

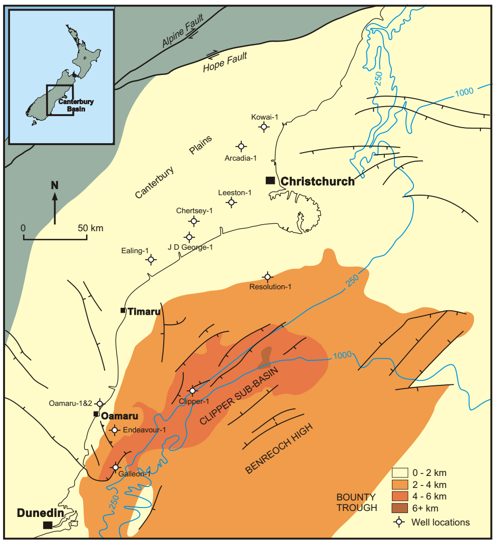
The Great South offshore basin covers approximately 100,000 sq km near the southeast coast of the South Island (see figure below). To date eight offshore wells have been drilled with discoveries reported at Kawau-1 (flowed 6.8 mmcfd) and Tora-1. There are as yet many undrilled structures at several levels. Structural traps associated with potential mid-Cretaceous reservoirs have not yet been assessed in detail, and stratigraphic traps are unexplored.

There is significant interest in exploration with Crown Minerals currently placing exploration licenses out for tender. It is reasonable to expect, that after a period of quiescence, active exploration will recommence in the next several years. Commercial exploitation, however, if successful, could well be at least a decade



Great South Basin (www.crownminerals.govt.nz/petroleum/basins/ map-grtsth.html) away when the world may be facing a different global supply situation.

The Canterbury basin (see figure below) also has a proven petroleum system with large mapped structures and a significant (sub-economic) offshore discovery. The Galleon and Clipper wells drilled in the late 1970s and early 1980s contained significant hydrocarbon flows, but was plugged and abandoned as the calculated recoverable reserve was deemed uneconomic at the time. Onshore wells drilled to date have been dry. There remains a range of potential source rocks in the basin yet to be drilled with primary reservoir targets late cretaceous or eocene sandstones, with potential similar to the Taranaki Basin. Further exploration can be anticipated in this basin.



Canterbury Basin (www.crownminerals.govt.nz/petroleum/basins/ map-grtsth.html)

GAS/LPG

Liquefied petroleum gas (LPG) is the only available heating gas in Otago. LPG (typically a mixture of propane and butane) is delivered to Otago by both ship and rail. LPG sold in the Otago region has relatively high propane content as it provides for better stability in the colder conditions.

The Maui and the Kapuni oil fields are the main sources of the LPG delivered into Otago. There are two main suppliers – Todd Energy, trading as Nova Gas (ex Citigas), and Rockgas (owned by Origin Energy). The Todd Energy Group has a substantial shareholding in the Kapuni oil field, and this field has the largest remaining reserves of gas as the Maui field rapidly becomes exhausted. Rockgas sources its gas from the Maui field, and between 2006 – 2008, additional gas is to be imported from the Philippines to meet winter gas demand. Todd Energy is a New Zealand owned energy company, with a 50% shareholding in Shell Todd Oil Services (STOS). Shell NZ owns the other 50%. Under agreement dating back to 1955, STOS is the operator of both the Kapuni and Maui oil and gas fields, and the associated production equipment.

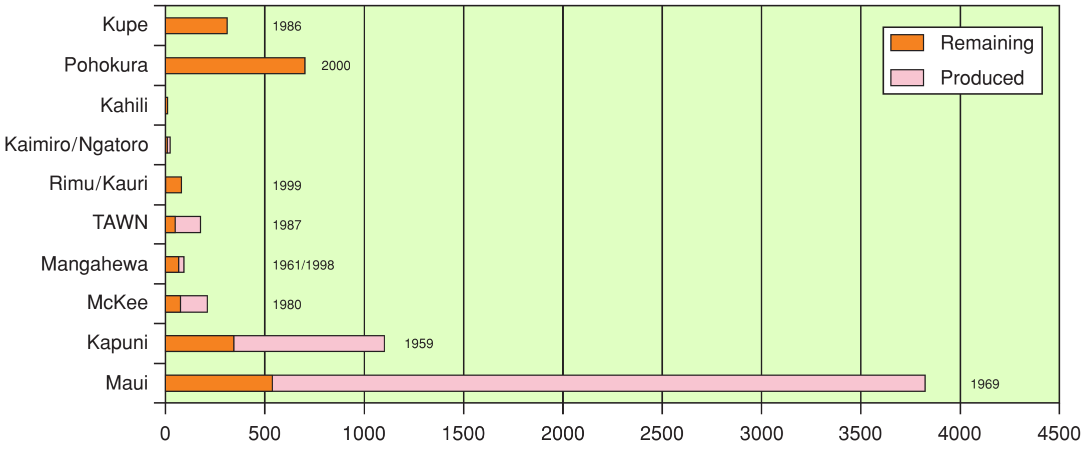
There are also two smaller players in the Otago market; Shellgas and ON-Gas (BP). Both of these companies have substantial activities in other parts of New Zealand and are expanding into Otago.

Future Sources

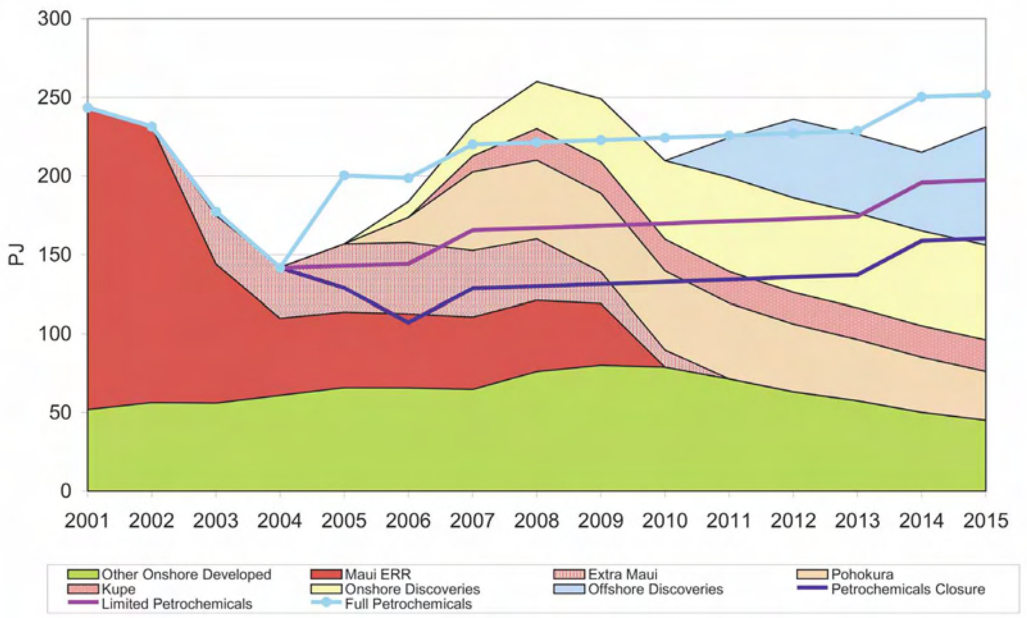
Beyond the Canterbury and Great South basins there are a number of other non-conventional sources for fuel gas. The Green Island Landfill will have a gas collection system installed over the next few years, with the tendering process in motion at present. However, at this stage, the intent is only to comply with the Ministry for the Environment requirement concerning methane emissions from landfills, and it is expected that the gas collected will be flared. Should sufficient gas be collected from this project, it is likely that a tendering process will be implemented to use the gas. One of the options would be to add it to the reticulated gas system in Dunedin.

A previous effort to extract landfill gas from the Green Island Landfill saw the installation of a 100 mm, 8 bar pipeline from the GI Landfill to the Novagas (ex Citigas) Hillside road depot. Additional infrastructure relating to this project, which was abandoned in October 1999, may still be present should sufficient gas be available in the future.

There has been considerable interest and exploration for coal seam gas associated with the Otago lignite deposits as well as other coal resources in the region (see next section). L&M Group have announced commercial quantities at their Hawkdun interest and are currently assessing the business case for commercial exploitation. It is likely that any commercial



New Zealand gas reserves showing the depletion of reserves during the Maui era (PJ)



Supply capacity of developed gas fields, those nearly ready for development, discovered reserves and possible new discoveries

project will be based on electricity generation. Another option is to use the vast lignite coal reserves in the Otago and Southland regions to produce synthetic natural gas (SNG). The lignite resource has the capacity to produce the equivalent of several Maui gas fields should such an option be pursued.

Whilst the gasification of lignite coals to SNG is well proven, development of these reserves are more likely to be directed towards the manufacture of transport fuels; with pipeline gas and electricity generation a by-product of the main synthesis route. Commercial exploitation is at least 10 years away.

COAL

Two types of coal are available in the Otago region, lignite and sub-bituminous coal. Lignite is a relatively low-grade coal, with a low heating capacity and often a high ash content.

Current production in the region is limited to the Kai Point mine in Kaitangata, near Balclutha and Roxburgh. Sub-bituminous coal has a higher energy content, contains less moisture and is available from both the Ohai and Kai Point mines.

2005 national coal production totalled 5,267,162 tonnes from 28 mines, production totals & the number of mines annotated on this map are not exhaustive.

Coal resources in New Zealand

There are three main suppliers of coal to the Otago region. Solid Energy operates the Ohai mine in Southland, and Kai Point Coal operates a mine at Kaitangata, near Balclutha. The coal from the Ohai mine is of higher quality than that from Kai Point, with lower ash content, and lower sulphur content. Sulphur is a major contributor to air pollution unless treated.

There is also a small coalmine at Roxburgh, which provides coal to the surrounding areas. This latter supply contains both lignite and some sub-bituminous coal.

Production of Coal in Otago

The Kai Point coalmine produces about 50,000 tonnes of coal a year, and the Roxburgh mine about 7,000 tonnes a year. In Southland, the Ohai / Nightcaps mines produce about 174,000 tonnes of sub-bituminous coal; a proportion of which is consumed within Otago. In Southland, a further 238,000 tonnes of lignite is produced (2004 figures), although little of this will be entering Otago. In 2004 New Zealand produced 5.2 million tonnes of coal, which included 2.4 million tonnes of sub-bituminous coal and 2.5 million tonnes of bituminous coal. The total energy value of the coal produced in New Zealand in 2004 was 132 PJ of which 50% was exported.

Coal Resources in Otago

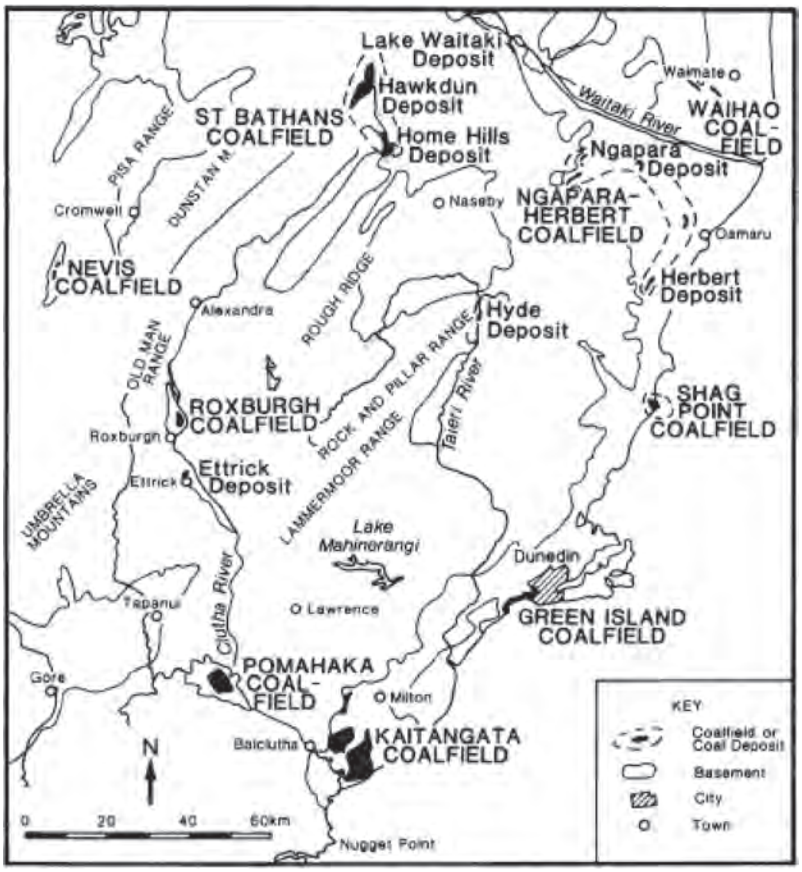
Otago has substantial lignite resources at St. Bathans, Kia Point and Roxburgh. This coal is very suitable as a feedstock for conversion to transport fuels, fertiliser, methanol and other products as well as utilisation for power generation. It is low grade, high moisture content and is thus less preferred against higher rank coals for conventional thermal uses.

Development of these resources is under active investigation by a number of interested parties. The lignites are amongst New Zealand's most important energy reserves. Recent studies suggest an as-mined energy cost of somewhat less than $US 1/GJ; making these resources amongst the most competitive energy resources available world-wide.

One of the preferred development pathways envisaged is for a world-scale, integrated development using gasification technologies and Fischer Tropsch synthesis to produce a low sulphur diesel (FT diesel) suitable for the advanced engine technologies now emerging in Europe. Rising crude oil and fuel prices are driving the search for cheaper options. In this part of the world there are currently announced plans for a gas to liquids project in Australian based on gas reserves in the NW Territories as well as competing projects based on Victorian brown coals – the latter has feedstock similar to the Otago lignite.

Published data suggest that these projects are more than competitive with new oil at current price levels. World scale plants of this type require a unique set of conditions to ensure commercial viability, critical is host country support and the infrastructure – both physical and human – required to support the billions of investment involved. It will be several years yet before the prospects for commercial exploitation can be fully determined.

An unrealised issue remains the likely CO_2 emissions related with this type of activity.



Coal resources in the Otago region

International research activity is now at the point where geosequestration is being commercially demonstrated. New Zealand has an active involvement in these programmes and is thus well placed to take advantage of international best practice in this area.

Preliminary life cycle analysis from mining to end-use for the manufacture of F-T diesel undertaken by CAE shows that the comparative emission factor ranged between 0.5 to 2.0 times the emissions arising from the manufacture and supply of conventional diesel, depending on the processing scheme adopted.

Government policy and economic factors will ultimately determine the optimal level of carbon capture required of any commercial facility.

ELECTRICITY GENERATION

The regions existing generation resources are listed below. New generation forecasts are limited to publicised proposals and are an understatement of long term opportunity but also remain uncertain in the short-term because of competition effects (first in will satisfy marginal demand opportunities). Note that the proposed maximum development potentials have been listed. It is unlikely that all these maximum capacities will be realised within the near term for the above reason.

All the Otago network companies, except Network Waitaki, prior to separation in 1999, had hydro generation embedded in their networks:

- Central Electric in Central Otago had the most capacity relative to load. Most of this was built on the back of its irrigation heritage. It sold generation assets to Pioneer Generation Ltd, which remains a local generation company.
- Dunedin Electricity sold its Waipori Scheme to Trustpower and its energy trading to Contact Energy.
- Otago Power sold its Paerau hydro and energy trading to Trustpower.
- Network Waitaki had no generation of its own but sold its energy trading to Meridian Energy.

PIONEER GENERATION

Currently the only electricity generator solely for regional supply is Pioneer Generation. The trust-owned company is head-quartered in Alexandra with two staff working from an office in Ranfurly. It has a retail line business in joint venture with Aurora Energy Ltd, and its energy trading is sub-contracted to Trustpower. Pioneer Generation Limited owns, operates, and maintains twelve power stations in Otago and one in Southland.

Many of the small hydro electric power schemes owned by the company were developed originally in cooperation with gold

Generation Station	**Commissioned**	**Rated Output (kW)**	**Annual Generation (GWh)**
Lake Onslow	1984	1.8	
Horseshoe Bend	1999	4315	17
Michelle	1982	1600	13.2
George	1924	1000	8.2
Teviot Bridge	1972	1125	4.3
Ellis	1981	6800	45
Fraser	1954		20
Wye Creek	1929	348+1000	10
Glenorchy	1969	500	2
Falls	2003	1200	9
Lower Roaring Meg	1936	2000+1000	24
Upper Roaring Meg	1947	513+750	9
Monowai	1925 &1927	2000+2000+2000	30

Pioneer Generation hydro-electric power schemes in the Otago region

Generation Station	Rated Output (kW)	Annual Generation (GWh)
Waipori 1	8900	NA
Waipori 2	57500	NA
Waipori 3	7600	NA
Waipori 4	8200	NA
Paerau	10000	47.8
Patearoa	2250	7.5

Trustpower, Waipori and Paerau Gorge power schemes generation

mining, dredging and irrigation companies, providing the only source of electricity to the region until connection to the national grid in 1957.

TRUSTPOWER

Trustpower owns, operates and maintains two hydroelectric schemes in Otago, the Waipori hydro and the Paerau gorge power schemes.

The Waipori scheme comprises of four dams and power stations on the Waipori River in the Lammerlaw Range. The topography of the upper Waipori River catchment provides the ideal setting for generating hydro electricity. After a winding course the river emerges into a valley of 27 km in length but with only a 30m fall, providing the ideal setting for Lake Mahinerangi. In contrast this valley becomes a narrow gorge with a sharp decent of 165m over 4 km, giving the fall necessary for water to drive the turbines.

The system begins near the headwaters of the Waipori River, high in the Lammerlaw Range. A web of water races, open channels, diversion tunnels and pipelines feed the scheme beginning with the 2,000 hectare Lake Mahinerangi and Station 1 below the dam.

The Paerau Gorge power scheme is a combined power and irrigation scheme operated by diverting the Taieri River's flow at Paerau using a substantial weir structure in the river which maintains the water level into the scheme while allowing floods and a minimum river flow to pass. The scheme's inflow passes along an aqueduct through substantial cuttings and a 1.3 kilometre long tunnel before feeding the Paerau Power Station. The outflow from the power station fills a large ponding area from which the irrigation scheme and Patearoa Power Station draw. The irrigation scheme now extends for 35 kilometres down the western side of the Maniototo basin. The east side proposal is limited to the second power station near Patearoa which discharges back into the Taieri river.

When low flows occur during summer, supplementary flows will be released from the Loganburn Reservoir formed at the site of Great Moss Swamp to ensure minimum river flows are maintained and that sufficient irrigation water is available to the scheme.

OTHER REGIONAL POTENTIAL HYDRO

The **Clutha** catchment has:

- the largest catchment area of New Zealand rivers.
- the highest mean flow
- existing hydro-electric power stations (e.g. Roxburgh, Clyde),
- controlled lake storage (Hawea)

Contact Energy operates the Clutha River based power stations as well as being a major landowner in the Luggate, Queensberry area (between lake Dunstan and Lake Wanaka). Additional schemes identified in the catchment are set out below.

In addition to these, Pioneer Generation Ltd commissioned a 1.2MW power station at Falls Dam (2003) within the Manuherikia.

The 30MW Contact Energy scheme at Hawea consists of replacing the existing works used to control the discharge from the lake with a 30MW hydropower scheme. The 60MW scheme in total diverts water downstream of the 30MW

Name	MW	Average Energy Production (GWh p.a.)
Manuherikia River	7	23
Luggate	90	435
Queensberry Hills	180	860
Hawea*	90	435
Nevis	45	197

* consists of two schemes

Hydropower opportunities in the Clutha Catchment with high to medium confidence of proceeding in the next 20 years

Name	MW	Average Energy Production (GWh p.a.)
Taieri Falls	8	35
Lower Taieri	18	79
Taieri - Deep Stream	7	30
Taieri - Lee Stream	7	31

Hydropower opportunities in the Taieri Catchment with high to medium confidence of proceeding in the next 20 years

scheme and conveys it by canal across country where it will finally enter a 60MW power station on the Clutha River.

Taieri catchment has:

- existing hydro-electric power stations (e.g. Waipori, Paerau),
- associated controlled lake storage (Mahinerangi)

Other undefined hydro opportunities include:

- Clutha catchment
- Lower Clutha - 350MW
- Dumbarton Rock - 110MW
- Manuherikia River Irrigational Hydro Dunstan Creek - 7MW
- Upper Fraser River - 7MW (h-bend)
- Teviot River “C” - 6MW
- Staircase Creek - 5MW

POTENTIAL Wind

The Otago region is noted for its wind potential with the region probably subject to more investigation than almost any other region in the country. Significant capacity has been identified with announced projects including:

- Meridian Energy **Lammerlaw Ranges** (project Hayes). Up to 630 MW, 1st stage 150MW, freehold farmland, up to 176 Turbines. This will be the biggest wind farm in NZ if it goes ahead.
- TrustPower **Lake Mahinerangi** (South of Dunedin). Up to 300MW, 100MW increments, Close to Waipori power stations.
- Meridian **Rocklands** near Benmore. Up to 1000MW, connected to HVDC link for conservation of hydro levels.
- Roaring 40s (Australian Company) **Cairnmur Range** near Cromwell. $150 million windfarm with the next 2 years
- Investec Bank (Australian) **Mt Benger** near Roxborough. Has been granted resource consent to install two monitoring towers
- Windpower Otago **Rock and Pillar Range**. Proposing 25MW wind farm.
- **Pisa Range** near Cromwell. Only rumours.

Clearly, of the above, the larger schemes will be grid-connected and, as such, will have a limited impact on local supply. Smaller schemes, however, will be embedded within the local distribution network and may well face financial constraints from network enhancement costs and technical requirements for connection. This is discussed further in later sections of the report.

BIOFUELS

Beyond domestic wood supply, the absence of any significant wood processing industry in the region limits biofuel application. There may be some niche opportunities for cogeneration, and possibly bio-diesel made from tallow supplies in the region. However, international literature suggests that commercial manufacture of bio-diesel requires industrial scale plant and feedstock diversity to overcome the seasonal nature of tallow supply.

GEOTHERMAL

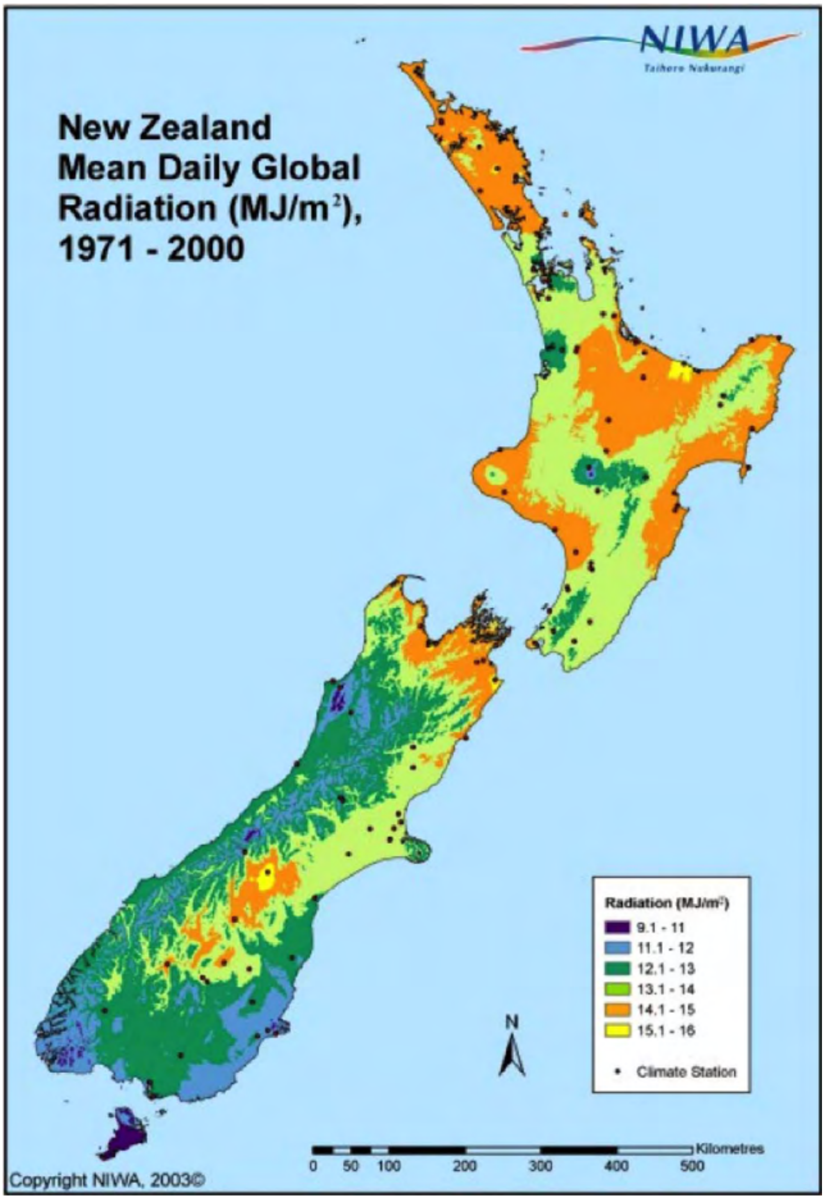
Anecdotally, according to GNS, there is not much data, but some indications of high heat flow relative to the surface. Temperatures in Takapu-1A (see well location in Petroleum section) were quite high and the calculated heat flow is ~90 mW/m² and a similar heat flow has been detected from Macraes Flat. GNS have identified a helium3/4 anomaly from a spring near the Otago Peninsula that suggests that there is a fluid connection to the mantle. However, in the absence of any drilling, this potential remains theoretical at best.

SOLAR

Solar energy can be directly harnessed in various forms, such as solar hot water heating, electricity generation via photovoltaics or through passive solar space heating. This energy form is of course very dependent on sunshine hours and the suitability of the type of technology used.

Solar Radiance in New Zealand

The map below of mean daily solar radiation



for New Zealand is based on an interpolation of climate station data collected during the period 1971–2000, undertaken by NIWA's National Climate Centre. This map is indicative of the type of data required for proper assessment of solar potential.

The various solar technologies are briefly described below. No data could be found on the specific uptake and suitability of these technologies in the Otago region, but the University of Otago is running a long-term trial of solar hot water heating technologies in Dunedin.

SOLAR HOT WATER HEATING

Solar hot water systems available in New Zealand are modular in design and have several variants:

- Glazed flat plate collector.
- Evacuated glass tube collector.

Of these systems, there are also variations of heat flow design:

- Passive (thermosiphon) (40% of sales).
- Active (pumped flow) (60% of sales).

Flow may be either in an open or closed loop heat transfer configuration.

Glazed flat plate systems are the most common collector available, although most new entrants to the industry are offering imported evacuated glass tube collectors. Most solar water heating systems are available as standard packaged units for installation for residential applications.

Systems are installed with provision for electricity or gas energy boosting during periods of low solar input. The pumped system can be connected to existing hot water storage cylinders and is often installed when retrofitting onto an existing house, motel, rest-home, etc. Hot water cylinders for pumped systems can be located anywhere in or outside a building.

Either a pumped or thermosiphon system may be used when a new structure is being built or an existing hot water cylinder requires replacement.

Specific commercial or industrial applications generally involve more complex design and have so far not been widely adopted; despite technical and economic feasibility. In industrial applications solar energy will often be a pre-heater for other conventional heat plant. The solar components may be arrays of conventional domestic systems or specific designed arrays of collectors to large volume hot water tanks.

PHOTVOLTAIC (PV)

PV is an emerging industry with international manufacturing approaching economies of scale that are leading to associated price reductions. The conventional industry based on silicon has reached a price plateau due to competition with the semiconductor industry for silicon. The big new changes are in copper indium gallium diselenide. To date, New Zealand has largely ignored solar PV, yet measured insolation levels are around those of Germany, which is number two in the world for PV usage. The majority of PV applications in NZ are off-grid with several suppliers providing packaged PV and PV/diesel hybrid systems, grid-connected and standalone. The Photovoltaic Association estimated in December 2004 that there was 1.4 MWp installed in New Zealand.

PASSIVE SOLAR SPACE HEATING

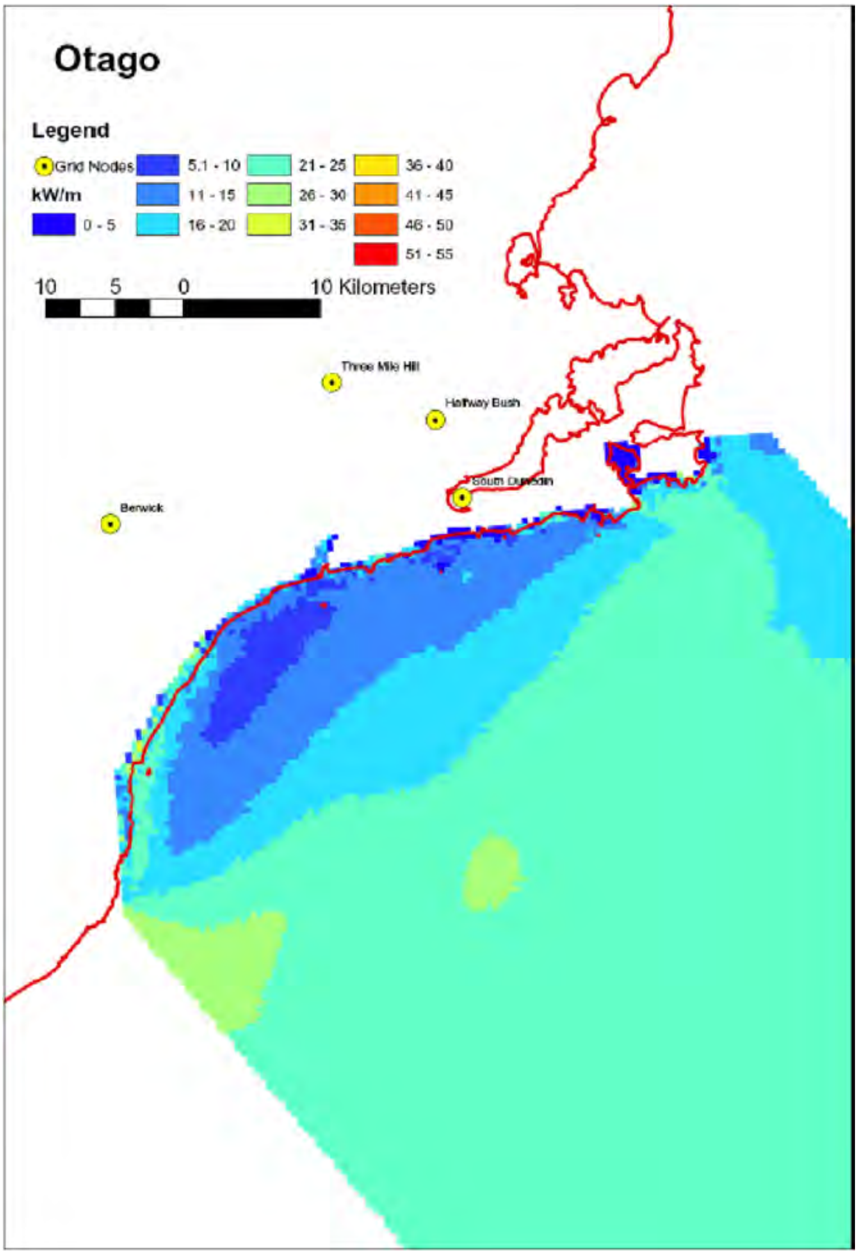
Passive solar design can greatly reduce energy consumption in buildings. It involves the collection, storage and distribution of thermal energy to provide warmth to the inside of the building. It therefore requires careful consideration at the design stage. New Zealand homes, typically, do not employ these design techniques to any extent and thus the opportunity is lost until replacement (>50 years on average).

TIDAL & WAVE

Tidal and wave energy generation are still very much development technologies, although internationally significant research and development is taking place. The Otago has a reasonable expanse of coastline, but limited to opportunities to make grid connections to and around Dunedin.

The figure on the facing page shows wave energy potential in the area around Dunedin.

Wave energy devices can be land based or



Wave energy potetial around Dunedin

moored in varying depths of water. The average wave energy incident on the Otago coast around Dunedin is 18.1 kW/m, based on NIWA data.

New Zealand's tidal range is 2-3 m and no significant intensifying embayment exists. This range is low compared to the global ranges so the tidal energy resource exploitable from tidal range devices is limited.

However there are a number of locations where the tidal currents are significant, particularly through sections of Cook Strait as well as the "narrows" at the exits of some harbours, providing opportunities for tidal current devices.

The Dunedin Harbour has a tidal range of approximately 1.8 – 2.0 m from the spit to Dunedin. Because of the shipping activity in the harbour, tidal devices in the main channels may not be feasible but narrows (such as the culverts under the rail lines) may offer an opportunity for small generation units.

Distributed Energy

The table overpage sets out current known or planned Distributed Generation (DG) facilities

	District	GXP	Gen. Co.	Scheme	Class	Type	2006 MW	2016 MW
	North Otago							
1		Waitaki	NWL	Standby	DG	Diesel	0.5	0.5
2		Black Pt					0	0
3		Oamaru	NWL	Standby	DG	Diesel	1	1
4		Oamaru	NWL	proposed	DG	Wind	0	5
5		Oamaru	NWL	proposed	DG	Hydro/Irrig.	0	3
		Total DG					**1.5**	**9.5**
		Total Grid					**0**	**0**
		Load Net of DG					**45.5**	**54**
	East Otago							
6		Palmerston					0	0
	Central Otago							
7		Naseby	Trustpower	Patearoa	DG	Hydro/Irrig.	12	12
8		Naseby	WindPower	Rock & Pillar	DG	Wind	0	70
9		Frankton	Pioneer	Wye	DG	Hydro	1.5	1.5
10		Frankton	Pioneer	Nevis	Grid	Hydro	0	40
11		Frankton	Pioneer	Glenorchy	DG	Hydro	0.4	0.4
12		Cromwell	Pioneer	Meg	DG	Hydro	4	4
13		Cromwell	Contact	Hawea	DG	Hydro	0	16
14		Clyde	Contact	Clyde	Grid	Hydro	432	432
15		Clyde	Pioneer	Fraser	DG	Hydro/Irrig.	3	3
16		Clyde	Pioneer	Tevoit	DG	Hydro/Irrig.	15	15
17		Clyde	Pioneer	Horseshoe Bend	DG	Hydro/Irrig.		
18		Roxburgh	Contact	Roxburgh	Grid	Hydro	320	320
19		Roxburgh	Meridian	Middlemarch	Grid	Wind	0	630
		Total DG					**47.9**	**133.9**
		Total Grid					**752**	**1422**
		Load Net of DG					**51.1**	**2.1**
	South Otago							
20		Balclutha					0	0
	Dunedin							
21		HWB-1					0	0
22		HWB-2					0	0
23		South Dunedin	Trustpower	Waipori (33kV)	DG	Hydro	40	40
24		South Dunedin	Consumer	Ravensborne	DG	Fert.	2	2
25		South Dunedin	Consumer	Airport/Port/Misc.	DG	Diesel	2	4
26		Berwick	Trustpower	Waipori (110kV)	Grid	Hydro	40	40
27		Berwick	Trustpower	Deep Stream	DG	Hydro	0	3
28		Berwick	Trustpower	Waipori	Grid	Wind	0	300
		Total DG					**44**	**49**
		Total Grid					**40**	**340**
		Load Net of DG					**120**	**156**

Known current and proposed Distributed Generation in the Otago Region in the Otago region. This listing is not likely to be complete, but is indicative of the type of DG opportunity available. Under reported in the table is diesel standby capacity. Other work undertaken by CAE of the opportunities for DG in New Zealand has suggested that there may be as much as 300MW of connected diesel in the country as a whole. Significantly more study is required to get to a level of regional data suitable for planning purposes. However, DG investment has significant regulatory and commercial barriers to overcome before widespread adoption is likely. Foremost among these are current market arrangements for non-utility generators and the regulatory limitations imposed on lines companies in respect of ownership and trading. These issues are discussed further in Section 6.5.

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4 CURRENT OTAGO REGION ENERGY SITUATION

4.1 ENERGY USE PATTERNS

DOMESTIC THERMAL

Coal, wood, electricity and LPG are all substitutes to varying degrees for space heating in the domestic sector. Other value-added fuels include briquettes, firelogs, and wood pellets. There are several elements that influence the choice of home heating fuel:

- Price
- Income
- Climate (temperature, humidity and wind)
- Convenience of supply
- Security of supply
- Housing stock
- Lifestyle

for further discussion on these factors and domestic heating options, see Section 6.1.

The figure below sets out 2001 data detailing fuel use for heating for the four major centres. As can be seen, electricity dominates but, uniquely, wood has a significant market share in Dunedin.

ENERGY CONVERSION EFFICIENCY

• Solid fuel burners	50%-80%
• Open fires	5%-15%
• Pot Belly	35%
• Wood Pellet fire	up to 90%
• Standard electric heaters	100%
• Heat pumps	200%
• Nightstores	80%
• Portable gas heaters	90%

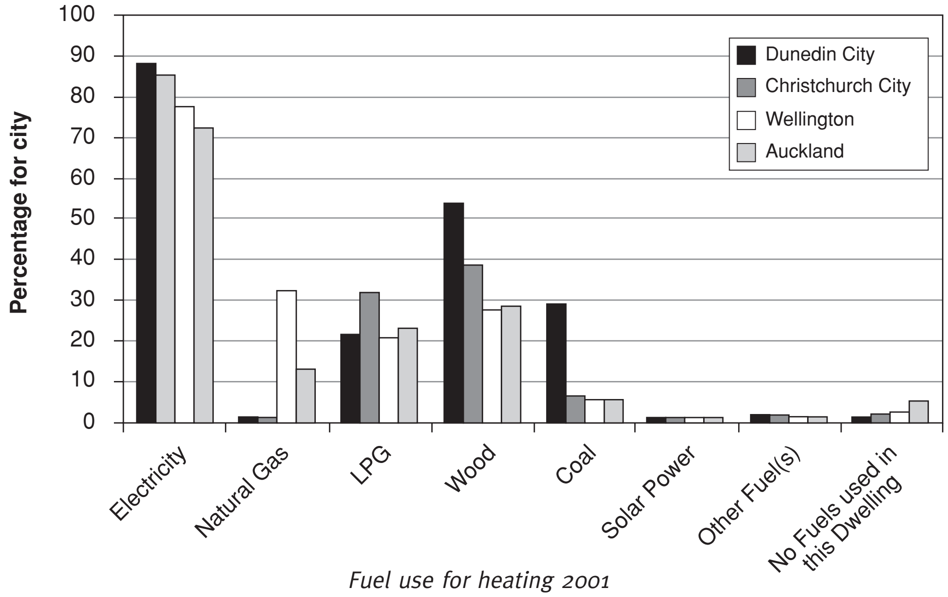
See Section 5.5 for a comparison of fuel prices based on conversion method efficiencies.

Wood

Because of scavenging and many small cash-based providers, demand for firewood nationally has been traditionally difficult to estimate. Sources of firewood include land clearing, forest arisings, small sawmills, wind thrown trees, and general scavenging.

In 1992 the Department of Statistics estimated that about 300,000 tonnes of firewood was consumed annually in NZ. This amounted to a consumption of around 235 kg per household per annum which would imply an estimate of around 10,000 tonnes per annum for Otago, or 3.4 gross GJ /house/year[1].

More recently, the BRANZ HEEP preliminary report indicates 3800 kWh yearly gross annual



Fuel use for heating 2001

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[1] Based on cosumtion figures and 2001 census data on number of households

Heating Fuels **Area**	**Wood**	**Coal**	**Total Dwellings** *(Includes Dwellings Specifying One or More Fuel Types Used to Heat Dwelling and No Fuels Used)*
Total NZ	582,267 (44%)	121,170 (9%)	1,302,717
Otago Region	42,474 (62%)	21,768 (32%)	68,847
Southland Region	23,127 (67%)	20,034 (58%)	34,332

Wood types used to heat dwelling (total responses) for private occupied dwellings, 2001 (Statistics NZ, 2001 Census)

energy input to houses in the form of solid fuel. (Averaged across all houses that mainly used solid fuel) Under the previous assumptions this value would be equivalent to 13.9 GJ / year, or 960 kg firewood. As 44% of houses nationally used mostly wood for space heating the above estimate would imply around 422 kg per household per annum nationally.

In a study of 100 Dunedin state houses with low-income tenants, the University of Otago observed 6.5 kg firewood per day average in July, for those who used solid fuels, and 10.5kg of coal. Assuming this level of consumption for 6 months of the year, and no other consumption suggests 1,180 kg firewood annually.

These three sources suggest a demand of between 41,000–51,000 tonne of firewood per year for residential space heating in Otago[2].

Legislation

The New Zealand Government has set a deadline for air pollution levels in New Zealand towns and cities to meet the National Environmental Standard for Air Quality by 1 September 2013. Should Councils fail to meet this standard, then air discharge permits, even for consented activities, may be revoked until the Standard is complied with. New air discharge consents will similarly be unable to be granted. Therefore, Regional Councils have a strong incentive to control air pollution in the areas under their jurisdiction. The main indicator for air pollution, as measured under the Standard, is the concentration of particles less than 10 micron in diameter (PM10). Other indicators of air quality under the Standard are the concentrations of nitrogen oxides, carbon monoxide, and sulphur dioxide.

One of the major causes of air pollution in Otago towns and cities is from the burning of coal, particularly in low efficiency domestic burners. Several towns in Otago suffer from inversion layers during the winter months, which acts to concentrate the air discharge emitted, leading to relatively high level of air pollution. Major problem areas in Otago include Alexandra, Arrowtown and Mosgiel. The figure opposite identifies towns currently categorised into four Airsheds, Airshed 1 tending to have the worst air quality problems and Airshed 4 the least.

In response to environmental concerns, Solid Energy has decided to phase out the domestic retail of coal in the Otago and Southland regions, and is replacing that business gradually by the introduction of pellet burners instead. Pellet burners use compressed wood chips in high efficiency burners and result in minimal air pollutants discharged.

The installation of new solid fuel burners into homes in areas that have been identified under Schedule 1.2 of the Regional Plan: Air for Otago is now restricted to those burners which have been shown to meet new standards for air discharge rates for domestic burners. Burners that fail to comply will not be granted resource consent.

The introduction of these new rules and Solid Energy's withdrawal from the market is likely to see a decrease in the consumption of coal for domestic heating purposes, and an increase in the usage of gas, electricity and wood pellets.

Gas/LPG

LPG is widely used in the domestic setting for space heating, cooking, and hot water heating. The main centres in Otago (Dunedin,

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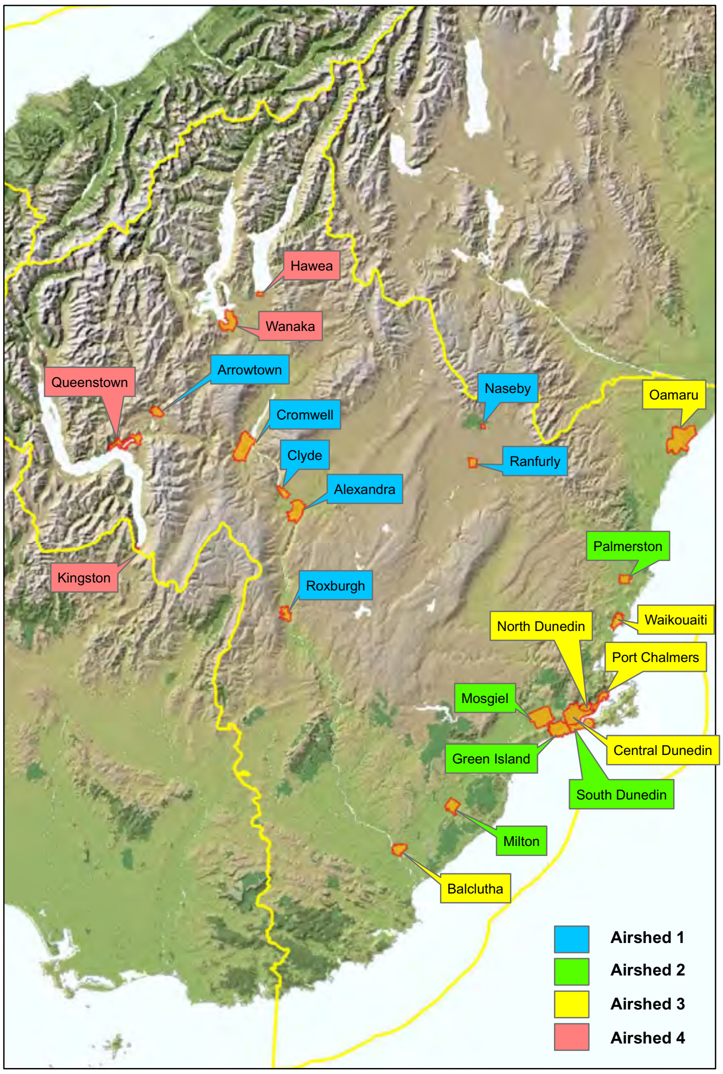
[2] EECA/CAE 1996 Quoted in Availabilities and Costs of Renewable Sources of Energy for Generating Electricity and Heat, Ministry of Economic Development (East Harbour Management Services), June 2005, p 116.



Areas effected by Regional Air Plan restrictions

Queenstown, Wanaka), and also Arrowtown, Luggate, and Lake Hayes all have reticulated gas systems in the Central Business Districts (CBD's) that are supplied by large storage cylinders filled from the Liquigas terminal (with the exception of Dunedin). Many new subdivisions in Central Otago also offer reticulated gas supplies.

People choose reticulated gas for a variety of reasons that include perceived cost benefits, fashion, and preference (e.g. stovetop cooking). Instant gas hot water systems are also commonly installed in new houses as people recognise the cost benefits of these systems. There is, conversely, a popular belief that 'gas supplies are running out', and that 'prices will rise rapidly', both of which are associated with the sooner than expected depletion of the Maui Gas Field. This is limiting some people from installing gas systems within their homes.

However, in 2007 the Pohukura field is expected to be producing, with the Kupe field and other discoveries following. New Zealand's domestic gas supplies, including LPG, are thus secure for at least several decades. LPG can also be reliably imported from Australia in the unlikely event of any shortfall.

In non-reticulated areas, LPG is only available in bottles. Typically, this involves 45 kg bottles, usually in pairs, which are refilled and reinstalled by the gas retailer. Storage of more than 90 kg of LPG requires a resource consent, and additional safety provisions are required to be met. For the typical house, 90 kg of gas will last between 1-6 months, if used for space heating, depending on usage and season. There is also a strong market for 9 kg gas cylinder bottles, which are refilled at service stations or bottle filling stations by the gas retailers. Commonly these bottles are used in portable appliances with low usage patterns (e.g. portable gas heaters, gas barbeques etc.) or for cooking use only.

4.2 MAJOR ENERGY USERS

GAS/LPG

Larger users of LPG will be on a reticulated system if possible due to convenience. Otherwise in the Otago region, coal and electricity compete strongly with LPG for these users. Larger users may also have their own storage cylinders on site, which are refilled directly by road tanker from the Liquigas Terminal.

In Dunedin, Todd Energy, through the reticulated system supplies the Dunedin City Council (Art gallery, swimming pools, Museum, Railway Station, Town Hall and Settlers Museum. In addition, Cerebos Greggs, the Abbotsford Brickworks and PPCS meat processing plant all use LPG for their operations.

Typically, these organizations have either no storage capacity on site (if connected to the reticulated system), otherwise 2-3 days of storage capacity is normal.

HEAT PLANT

There are a variety of boiler types used in the Otago region with outputs ranging from hot water through to super heated steam, and capacities up to an extreme of $35MW_T$. Coal and Lignite are the predominate fuel types used with wood waste used in saw milling operations and oil at Otago University.

See Appendix 2 for details.

LEGISLATION

It is unclear at this stage what the effect of the National Environmental Standard for Air Quality will have on the commercial and industrial sector as any consent granted is for a limited period. It is likely that in order to burn coal in the future, the granting of consents will increasingly require mitigation measures such as scrubbers. Additionally, should measures be adopted to charge for carbon emissions in the future, the use of coal will be further disadvantaged.

4.3 ELECTRICITY TRANSMISSION AND DISTRIBUTION

TRANSMISSION

The HV transmission assets located in the Otago Region have been developed primarily for interconnection of large state owned generation projects, and not to service regional load.

The region (including the Lower Waitaki that supplies North Otago) is a net exporter of electricity (around 75%). Regional load growth, in the absence of very large new loads, is a non-issue for the transmission and generation system to cope with.

Capacity is primarily driven by generation export requirements and similarly security/ load flow management focuses on large loads outside the region e.g. Comalco to the south, Christchurch to the north, and, as well, the DC link. With the exception of picking up the Clyde generation on the way, the region’s transmission is largely just an interconnection between Southland and the Waitaki.

DISTRIBUTION

There are three electricity network companies in the Otago region. These three companies have different ownership structures and different company associations, which drive different commercial imperatives. Each are described, in turn, below.

Network Waitaki Ltd. (NWL), which services North Otago from the Waitaki River down to Shag Point. Their area of supply includes significant areas outside the Otago Region, such as the Waitaki Valley (where they derive their transmission supply from) and the Hakataramea Valley. They must therefore interface with two Regional Councils and two District Councils.

The network is a typical rural network, of average rural consumer density (6.2 connections/km), comprising thirty-six 11kV distribution feeder lines emanating from eleven 33/11kV zone substations. The zone substations are all radial connected to their Grid Exit Point (GXP); i.e. no rings. Therefore supply restora-

South Island Electricity Network[5]

tion after any loss event is dependent on 11kV interconnection between substations.

Only the main urban substation, Chelmer Street, (supplying 30% of NWL's load) has n-1[3] security configuration with dual 33kV lines and transformers. Where 11kV feeders interconnect they are normally configured as open points. NWL's loadings are such that security provisions are generally focused on switching to restore supply quickly rather than targeting nil interruption.

Approximately one third of the 11kV network is 2-wire single phase and features a large amount of spur configuration limiting interconnection. This reflects the geographic remoteness of much of the network and the historical predominance of low energy intensity sheep farming.

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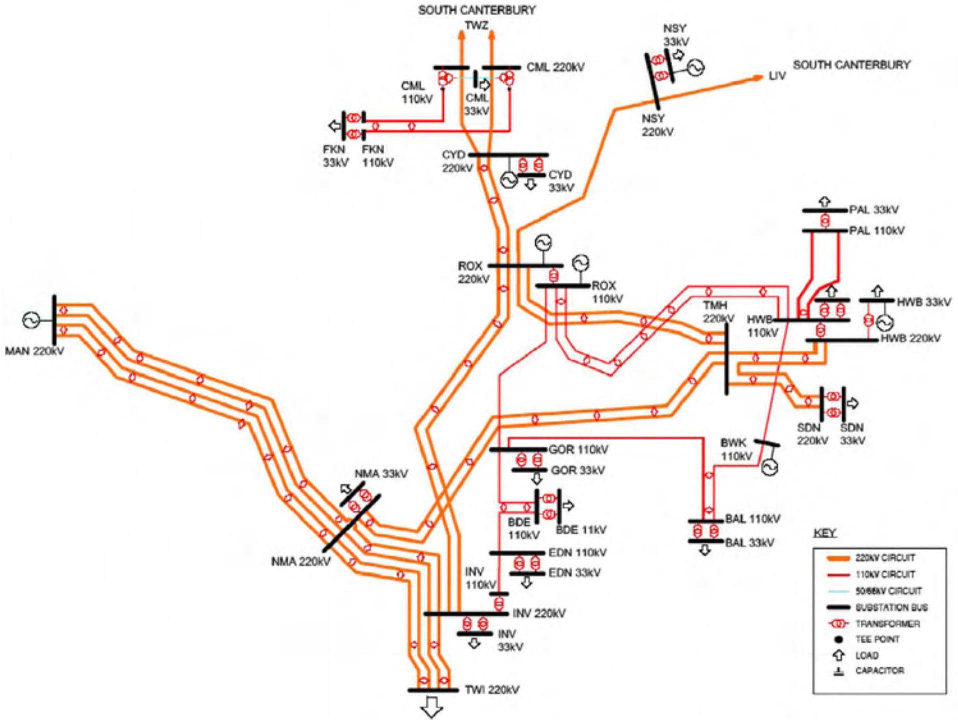
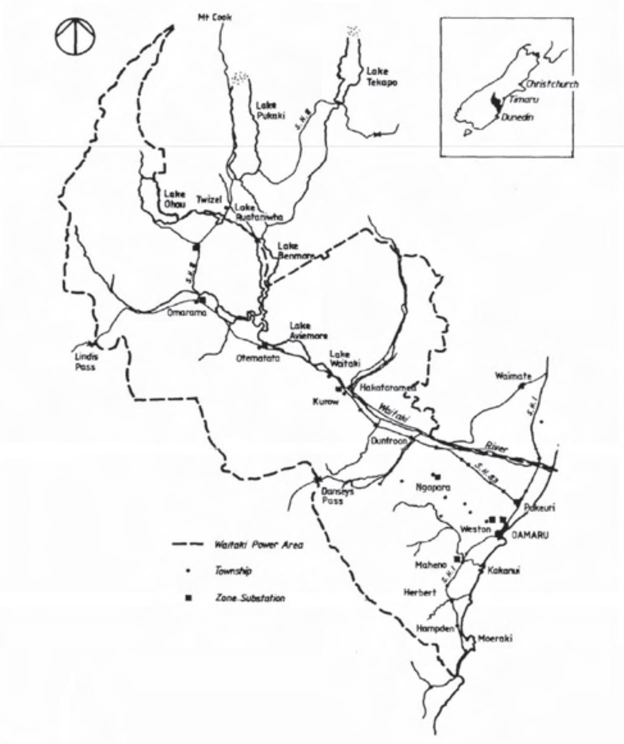
[3] n-1 indicates that this particular location in the network can suffer one component failure without loss of service.



Otago and Southland Transmission Schematic[6]

A 33kV sub-transmission network connects the zone substations to three grid exit points (GXP) at Oamaru, Waitaki, and Twizel. The Oamaru GXP has a maximum demand of approximately 28MW, and supplies 6 zone substations. The Waitaki GXP has a maximum demand of approximately 4.5MW and supplies five zone substations. The Twizel GXP is currently utilised solely as a backup supply for the Waitaki GXP to facilitate both NWL and Transpower planned



Network Waitaki area

maintenance.

Both current GXPs are now summer peaking but highly sensitive to variance in irrigation load. The Waitaki GXP peaks at New Year reflecting coincidence of irrigation and holiday making load. The Oamaru GXP tends to peak on the production season shoulders i.e. April. This is coincidence of the start of winter temperatures, extension of the killing season, dairy production, and irrigation.

The Waitaki GXP is constrained to 5MW capacity. In extreme scenarios the load can peak above this level for a few weeks forcing the use of the Twizel GXP with the corresponding transmission charge penalty. NWL has purchased three 635kVA diesel generators to enhance its peak demand management, defer transmission upgrade, and provide additional security options.

A new irrigation scheme is being installed in 2005, which will potentially add 2MW of load to the Waitaki GXP. The aforementioned generators provide NWL with the option of waiting for actual load to develop before making a major cost commitment of upgrading or permanently using an additional GXP.

Aurora Energy Ltd (Aurora) services two distinct geographical and electricity disjointed areas; Dunedin City and the Central Otago area formerly owned by Central Electric. Aurora is contained within the ORC area and must interface with several District Councils and a City Council.

The central region is characterised by separate valleys which have caused three radial network structures supplied from their centres via three separate grid exit points, with no interconnection between the structures. The Dunedin region is supplied by two grid exit points.

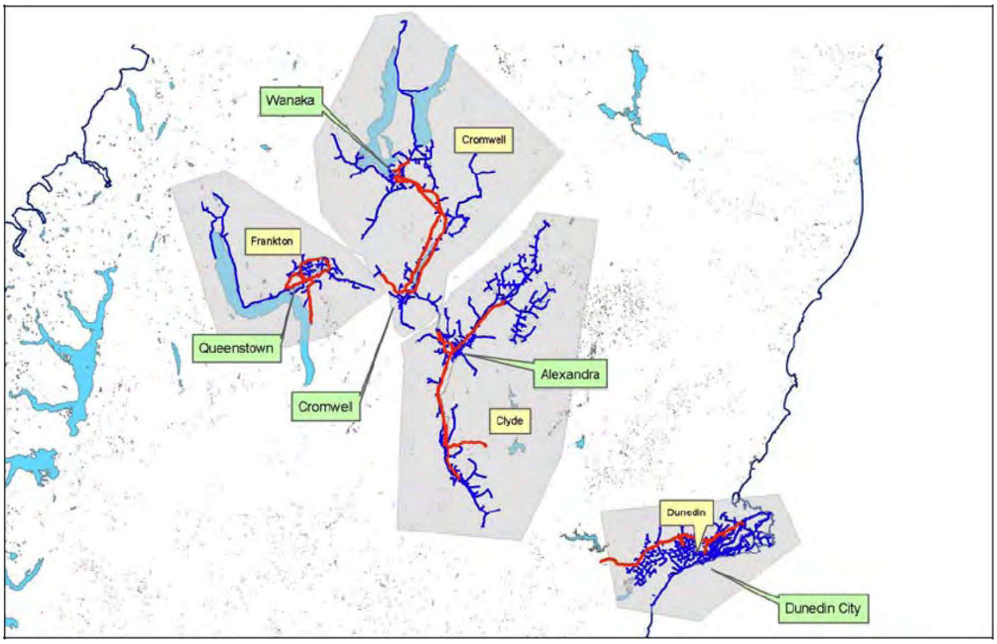
Large Consumers

The largest consumer that has a significant impact on network operations is the University of Otago with a peak load of 9MW and an annual consumption of 31GWh.

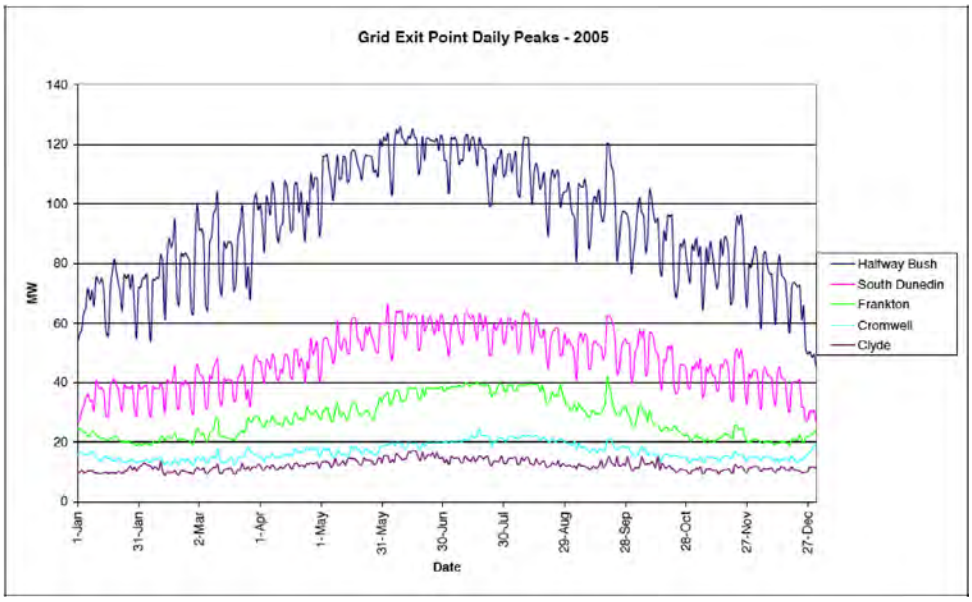
Load Characteristics

The load in all areas is dominated by residential and commercial load as there is very little industrial load. All GXP areas have their peak demand in winter. The 2005 daily peak loads for 2005 for each GXP are shown in the figure over the page.

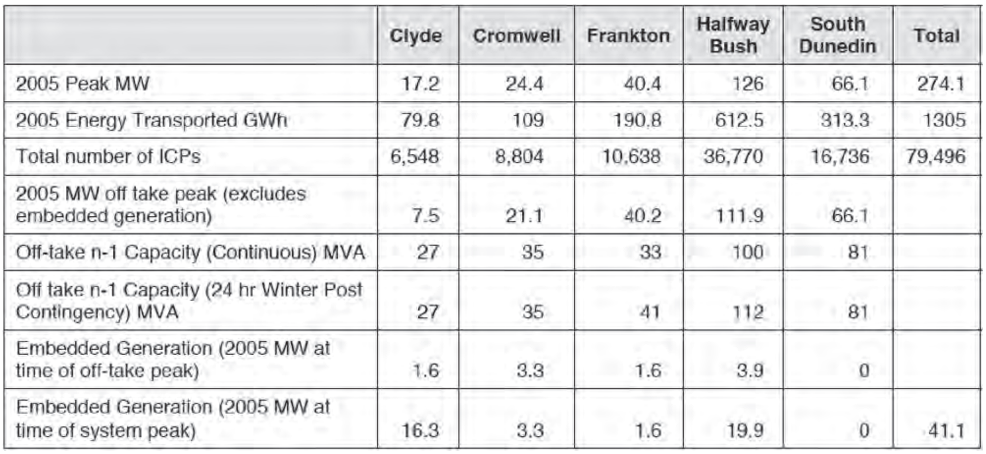
The Frankton and Cromwell GXP peak loads generally occur during the July school holidays due to the influx of skiers into the area. There has been significant growth in summer irrigation load from the Cromwell GXP such that one zone substation has a summer peak.



Dunedin Electricity (Aurora) Network area

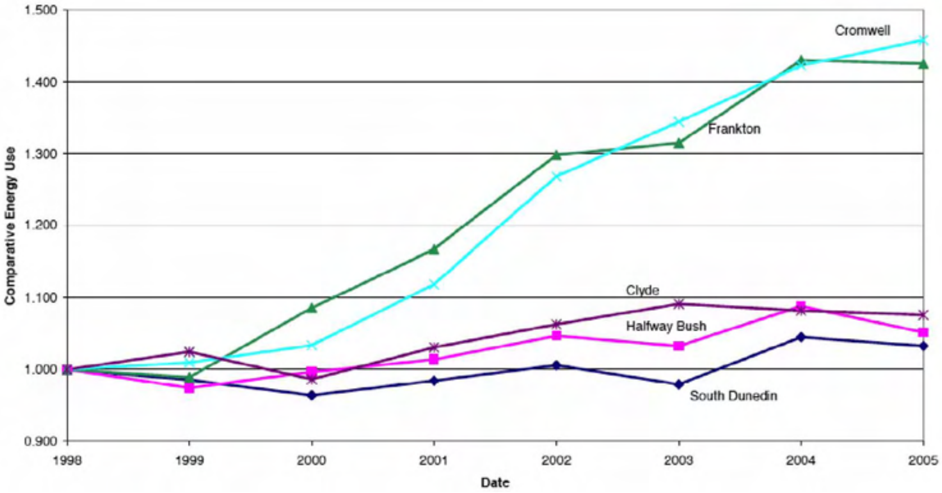


Aurora Grid exit point daily peaks 2005



	Clyde	Cromwell	Frankton	Halfway Bush	South Dunedin	Total
2005 Peak MW	17.2	24.4	40.4	126	66.1	274.1
2005 Energy Transported GWh	79.8	109	190.8	612.5	313.3	1305
Total number of ICPs	6,548	8,804	10,638	36,770	16,736	79,496
2005 MW off take peak (excludes embedded generation)	7.5	21.1	40.2	111.9	66.1	
Off-take n-1 Capacity (Continuous) MVA	27	35	33	100	81	
Off take n-1 Capacity (24 hr Winter Post Contingency) MVA	27	35	41	112	81	
Embedded Generation (2005 MW at time of off-take peak)	1.6	3.3	1.6	3.9	0	
Embedded Generation (2005 MW at time of system peak)	16.3	3.3	1.6	19.9	0	41.1

GXP load and capacity summary for 2005



Comparative GXP growth (GWH 1998 normalised)

The Clyde GXP serves Alexandra, Roxburgh and surrounding areas. This load also peaks in winter. An unusual characteristic of the load in some areas supplied from Clyde is the effect of frost fighting pumps during September and October that can put a large demand on the system for a short time.

Dunedin peak loads are very weather dependent and generally occur during a snowfall or low temperature event in the city, which can happen any time from May to September. This, of course, coincides with the period during which the system is at its greatest vulnerability from supply disruption. A peak load event is unlikely to occur during school holidays or at a weekend. The Dunedin load has a large variation between weekend and weekday loads which is not observed in Central Otago.

Strong growth is predicted to continue in the Frankton and Cromwell GXP areas and more modest growth in the Clyde and Dunedin GXP areas (see Appendices for maps of subtransmission network), as indicated on the GXP comparative growth chart on the opposite page.

The reduction of demand in 2003 was due to the government's energy savings campaign. The Dunedin 2002 peaks were due to an uncharacteristic 3-day snowfall in May.

OtagoNet Joint Venture Ltd (OJV) serves the three areas of South Otago (down to Clinton and Owaka), East Otago (from Waitati to Palmerston) and the Ranfurly end of the Maniototo. The Dunedin City network separates OJV south and east network segments. This is the network that was formerly owned and operated by Otago Power. It is also contained within the Otago Region but is subject to several District Councils.

The OtagoNet subtransmission network is supplied by grid exit points at Naseby, Balclutha and Palmerston. The network growth is shown in the energy and maximum demand from 1949-2005 in the chart over the page.

The main energy increase in 1992 and again in 2000 has been due to one large 24-hour industrial customer coming on line and then further increasing its load.

The reduction in maximum demand during the four years 1996-1999 was due to a policy of more stringent load control operations and milder winters, the demand increase since then more correctly reflects the system growth.

Naseby: The whole network is basically radial so that faults on one leg of each branch will cause a loss of supply to all customers along the branch with a supply security based on repair time.

One vulnerability in this area is the major customer, Oceana Gold, who is supplied through one long 66kV radial line. The 66kV line however is supplied through dual 33/66kV transformers at Ranfurly which in turn are supplied by the two 33 kV lines from Naseby. Oceana Gold is the only customer at the end of the 66kV line and it is its choice to remain as a single circuit supply.

Oceana Gold is expanding its mining operations and has requested additional power for its mining and processing operations. Options are presently being considered, which includes upgrading the 33kV network from Ranfurly to Deepdell to 66kV to cater for the increased mine load and local network growth.

Palmerston: The Palmerston, Merton and Waitati zone substations do not fully comply with the Company's security policy in that there is only one 33kV circuit and inadequate alternative 11kV supply into Waikouaiti.

The lesser concern is the Palmerston zone substation, which is only 2.5 kilometres from the Palmerston grid supply point.

Balclutha: The supplies to the two major customers, PPCS Finegand Freezing Works and the Fonterra Stirling Cheese Factory, both have alternative 33kV supplies or sufficient backup through the 11kV system to comply with the Company's security policy.

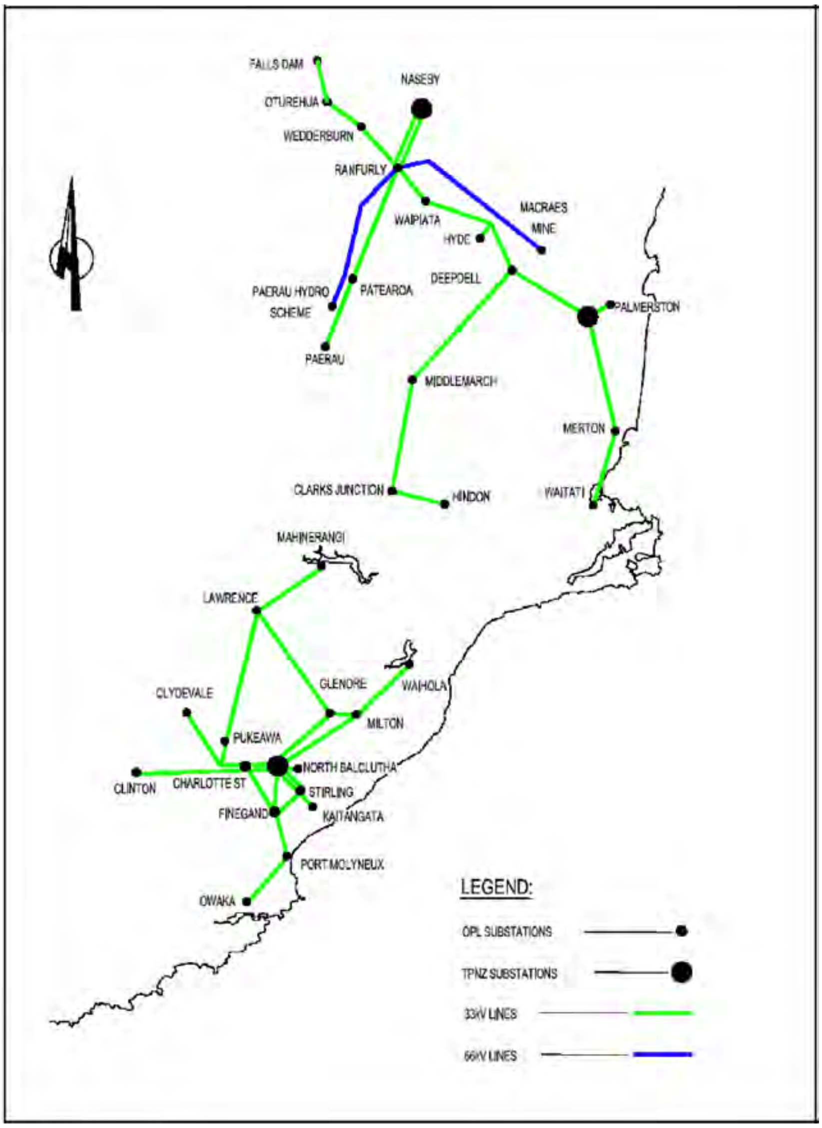
The zone substations at Balclutha, Charlotte Street, Pukeawa, Lawrence, Glenore and Elderlee Street are on 33kV rings and the zone substations comply with the security policy.

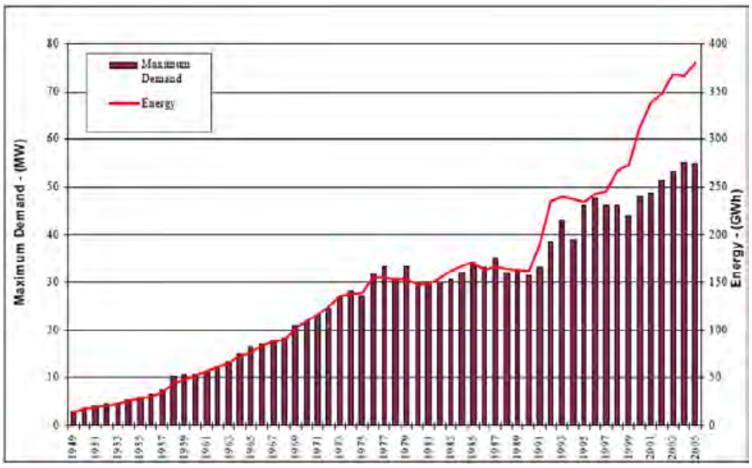
The two radial lines from Lawrence to Mahinerangi and from Elderlee Street to Waihola comply with the security policy, likewise the Clydevale and Clinton lines, however the increase in dairy farming in these last two areas will necessitate the need to provide further ties between and around the Clinton and Clydevale zone substations to satisfy the dairy customers. One 11kV enhancement between these substations is due for completion in 2006.

Owaka does not currently meet the Company's security policy, but it is a difficult and remote area to establish a backup line.

Two new customers are being established in the Milburn area in the next year. One is the Corrections Department facility for 300-500 inmates with its particular security and reliability requirements, the other customer is a timber mill with a large future load increase predicted if the timber market allows.

It is planned to build a new heavy 33kV line from Transpower Balclutha to Milton, this together with the existing lines will provide true N-1 availability into the foreseeable future. Appendix 4 describes in detail growth and security levels for individual substations.





Historic energy and maximum demand

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5 FUELS SUPPLY CHAIN

This section offers a brief overview of the fuels supply chain and regional energy price projections.

5.1 PETROLEUM

Petroleum products are received into Dunedin from bulk tankers discharging at the Fryatt Street Oil Wharf. The vessels are operated by Silver Fern, a tanker company jointly owned by all oil companies. Silver Fern Shipping Limited specialises in petroleum product tanker operations and is New Zealand's only tanker operating and management company. They operate two modern tankships.

Deliveries are usually made twice a month from the Marsden Point Refinery. A typical run would unload fuel at Timaru, Dunedin, and Bluff.

In addition, and on occasion, (maybe four times a year) a ship is received with refined stocks from Australia to top up deliveries from the NZ refinery.

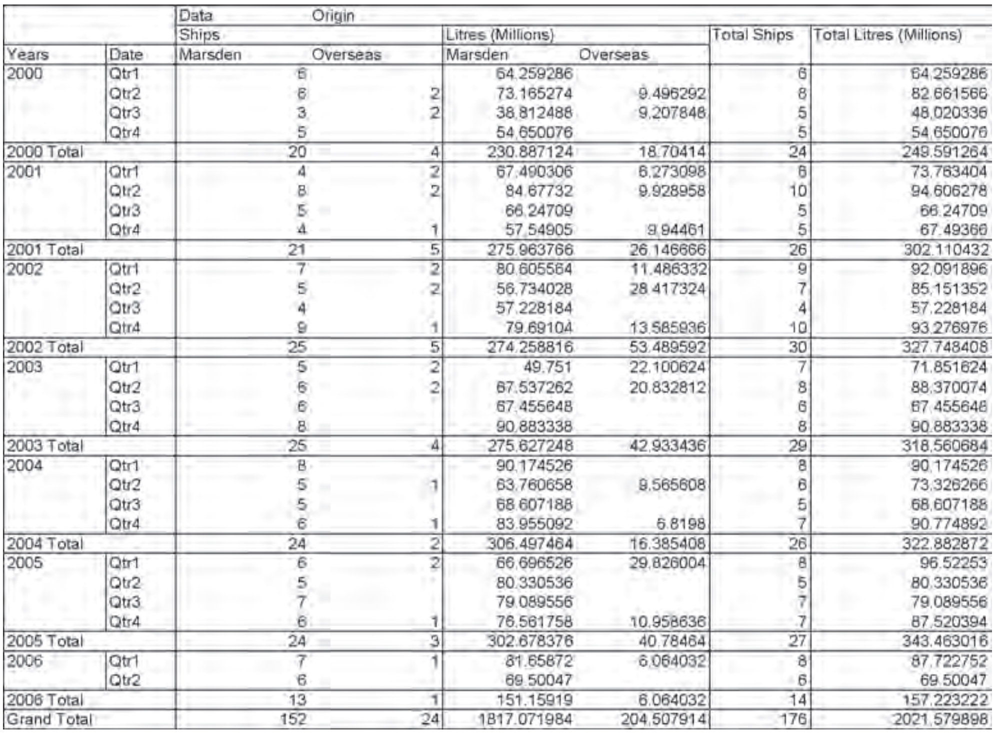
In 2004, there were 18 coastal and 3 international tanker visits into Dunedin. In 2005 there were 18 coastal and 3 international visits. In winter the schedule is typically 3-4 weeks between visits. There is some seasonal variation and in the summer delivery schedules are more like 2.5 weeks per tanker delivery. Although sometimes there are 2-3 deliveries in a week and then a two or 3-week gap as stock are drawn down.

From Fryatt street oil wharf, the product is transferred by pipeline to above ground storage tanks pending distribution to inland markets by road delivery vehicles or in the marine market via pipeline sales.

PRODUCTS

OIL/DIESEL

Only one grade of fuel oil is stored and distributed from Dunedin. Light Fuel Oil (or LFO 220 Secs) is stored at the Shell Oil Terminal and is delivered by road to commercial and manufacturing users who utilise it as a heating/boiler fuel.



		Data	Origin				
		Ships		Litres (Millions)		Total Ships	Total Litres (Millions)
Years	Date	Marsden	Overseas	Marsden	Overseas		
2000	Qtr1	6		64.259286		6	64.259286
	Qtr2	6	2	73.165274	9.496292	8	82.661566
	Qtr3	3	2	38.812488	9.207848	5	48.020336
	Qtr4	5		54.650076		5	54.650076
2000 Total		20	4	230.887124	18.70414	24	249.591264
2001	Qtr1	4	2	67.490306	6.273098	6	73.763404
	Qtr2	8	2	84.67732	9.928958	10	94.606278
	Qtr3	5		66.24709		5	66.24709
	Qtr4	4	1	57.54905	9.94461	5	67.49366
2001 Total		21	5	275.963766	26.146666	26	302.110432
2002	Qtr1	7	2	80.605564	11.486332	9	92.091896
	Qtr2	5	2	56.734028	28.417324	7	85.151352
	Qtr3	4		57.228184		4	57.228184
	Qtr4	9	1	79.69104	13.585936	10	93.276976
2002 Total		25	5	274.258816	53.489592	30	327.748408
2003	Qtr1	5	2	49.751	22.100624	7	71.851624
	Qtr2	6	2	67.537262	20.832812	8	88.370074
	Qtr3	6		67.455648		6	67.455648
	Qtr4	8		90.883338		8	90.883338
2003 Total		25	4	275.627248	42.933436	29	318.560684
2004	Qtr1	8		90.174526		8	90.174526
	Qtr2	5	1	63.760658	9.565608	6	73.326266
	Qtr3	5		68.607188		5	68.607188
	Qtr4	6	1	83.955092	6.8198	7	90.774892
2004 Total		24	2	306.497464	16.385408	26	322.882872
2005	Qtr1	6	2	66.696526	29.826004	8	96.52253
	Qtr2	5		80.330536		5	80.330536
	Qtr3	7		79.089556		7	79.089556
	Qtr4	6	1	76.561758	10.958636	7	87.520394
2005 Total		24	3	302.678376	40.78464	27	343.463016
2006	Qtr1	7	1	81.65872	6.064032	8	87.722752
	Qtr2	6		69.50047		6	69.50047
2006 Total		13	1	151.15919	6.064032	14	157.223222
Grand Total		152	24	1817.071984	204.507914	176	2021.579898

Oil Delivered to Port Otago Caltex Terminal 2000-2006

PETROL

Two grades of petrol are stored and distributed in Dunedin from Caltex Oil and BP Oil Terminals. Unleaded 91 Octane and Unleaded Premium 96 Octane are delivered by road vehicles throughout Otago (primarily to BP, Caltex, Shell and Mobil branded service stations), but also to individual farmers and commercial users. Diesel fuel, which is also known as AGO (Automotive Gas Oil), ADF (Automotive Diesel Fuel) or LDO (Light Diesel Oil), is stored and distributed from the premises of BP Oil, Shell Oil and Caltex Oil to all the above users and is also used extensively for road transport, rail, mining, manufacturing, contracting and the fishing industry.

AVIATION

Only one grade of aviation fuel, Jet A1 (aviation turbine fuel), is stored and distributed from Dunedin. This product is stored at BP Oil premises in Dunedin and delivered by road delivery vehicle to a small number of BP and Mobil customers. The principal user is the Air BP facility at Momona Airport with minimal amounts being delivered to other multi-user tanks at Wanaka, Queenstown, Te Anau and Taieri airfields.

Otago regional AVGAS is supplied out of Bluff.

SHIPPING

Light Fuel Oil is also used extensively as a bunker fuel and pipeline deliveries are made to vessels berthed at the Oil Wharf in Fryatt Street.

ROADING

Bitumen products, 180/200 and 45/55 Bitumen, are stored at the Fulton Hogan Bitumen Terminal in Fryatt Street and delivered by road vehicles to roading contractors in Otago and Southland.

BULK STORAGE

Bulk storage facilities are given in the table opposite.

SPECIAL USER

This category of user, having privileged access, is now somewhat limited in numbers as the modern trend is for fuel requirements to be uplifted from service stations/truckstops by way of a card system. Police, fire service, government agencies, local authorities, transport and contracting companies all utilise this option for the vast majority of their requirements. The following storage in Otago could still be classified as a special user category:

- Air BP - Momona Airport, approx. 150,000 litres Jet A1
- Tranz Rail - Strathallan Street 100,000 litres Diesel
- St. John Ambulance - York Pl. 10,000 litres Unleaded 91.
- Hospital other emergency stores

DISTRIBUTION

Stocks from Dunedin are generally delivered as far south as Gore and west to Central Otago. Queenstown is generally supplied out of Bluff. However shipments will go as far north as Timaru and, as well, to Queenstown or Invercargill as needed when storage tanks are low.

Four companies handle distribution to petrol stations, truckstops, airports, farms, and other fuel depots. There are a small number of independent retailers in addition to the majors.

Distribution companies in Otago may source petroleum from Dunedin, Bluff or Timaru for delivery into Otago. A list of distribtors is given in Appendix 7.

CAPACITIES AND RESERVES

Storage capacities include Dunedin city storage tanks at the port, and the tanks installed at various depots around the region. Port tanks total 45 million litres.

There are a total of 105 petrol stations and/or truckstops in Otago. Storage estimates made here are based on assumptions related to the size of individual stations.

The new “flagship” stations typically have 3 x 50,000 Litre tanks (150,000L), some maybe dual compartment 20/30. (13m x 2.4m). Older stations average 2 to 3, 20,000 Litres (50,000L).

Additionally some large businesses have

Location	Company	Tank	Contents	Capacity (millions of Litres)
Dunedin	BP Oil Parry Street	D1	Slops	2.2
Dunedin	BP Oil Parry Street	D2	Diesel	2.2
Dunedin	BP Oil Parry Street	D3	Unleaded 96	2
Dunedin	BP Oil Parry Street	D5	Diesel	2
Dunedin	BP Oil Parry Street	D6	Unleaded 96	1.5
Dunedin	BP Oil Parry Street	D7	Jet A1	1
Dunedin	BP Oil Parry Street	D8	Unleaded 91	6
Dunedin	Caltex Fryatt St	502	Unleaded 91	4.6
Dunedin	Caltex Fryatt St	503	Diesel	0.5
Dunedin	Caltex Fryatt St	529	Unleaded 96	4.2
Dunedin	Caltex Fryatt St	530	Unleaded 91	2.1
Dunedin	Shell	4	Diesel	6.8
Dunedin	Shell	7	Diesel	4.7
Dunedin	Shell	6	Light Fuel Oil	5
			TOTAL	44.8
Dunedin	Fulton Hogan Fryatt St	1	45/55 Bitumen	1.3
Dunedin	Fulton Hogan Fryatt St	2	180/200 Bitumen	0.5
Dunedin	Fulton Hogan Fryatt St	3	180/200 Bitumen	3.2
Dunedin	Mobil			Decommissioned

Oil product storage facilities[2]

storage tanks. Port Otago has one 50,000 Litres tank for diesel for port operations. Fishing boats mainly refuel out of the Dunedin terminal where oil arrives.

Thus (at (105x50,000) + (20x100,000)) around 7 million Litres of liquid petroleum fuel storage is estimated on site in Otago, which would amount to about 14% of a total bulk storage of around 52 million litres.

5.2 LPG

With the exception of Todd Energy, all the gas in Otago is sourced from the Liquigas terminal on Fryatt Street, Dunedin. The Liquigas terminal has a capacity of 1300 tonnes, and is serviced by a fleet of 5 ships, primarily originating from Taranaki, via Christchurch. The largest of these ships, the MV Victoire, has a capacity of 4000 m^3 of LPG. During the winter period, ships deliver LPG to the Liquigas terminal about once a fortnight. During summer, this frequency is reduced. The shipments are timed to allow for approximately 2 days of reserve capacity remaining in the facility (about 300 tonnes of LPG) to buffer against shipping delays. The Dunedin Liquigas terminal services the area south of Oamaru.

From the Liquigas terminal, the LPG is transported by truck either to the Rockgas 30 tonne cylinder on Hillside Road, or directly to the storage cylinders of other large users around the Otago region. ON-gas and Shellgas also use the Liquigas terminal.

Todd Energy uses rail to transport LPG from Taranaki to Dunedin, where the company has a 70 tonne storage facility on Hillside road, Dunedin. During the winter period, rail deliveries occur every 2-3 days, using up to 4 x 23 tonne capacity wagons. During very busy periods, the rail shipments are unable to meet demand, and in this instance Todd Energy can also access the Liquigas storage facility. Todd

Liquigas Bulk Storage Facility on Fryatt St by the Dedicated LPG Wharf

Energy supplies the reticulated gas system in Dunedin.

Until 1986, the reticulated system in Dunedin was supplied by coal gas produced at Andersons Bay Road. This was then changed to LPG and a new plant was commissioned in 1990. In 1995 Land fill gas (LFG) was added to the supply mix for a short time but this was discontinued due to the failure of the collection system. The insertion may soon be re-added as the land fill site is being reconstituted for gas collection.

The Liquigas plant was built in 1985 at Fryatt Street (electronically alarmed and protected against malfunction) and comprises eight storage tanks (135m^3 capacity each) which roughly equals one tanker vessel cargo.

There is are also a small number of special user LPG bulk storage facilities such as the brickworks at Abbotsford and the PPCS meat works on Dukes Road, Mosgiel.

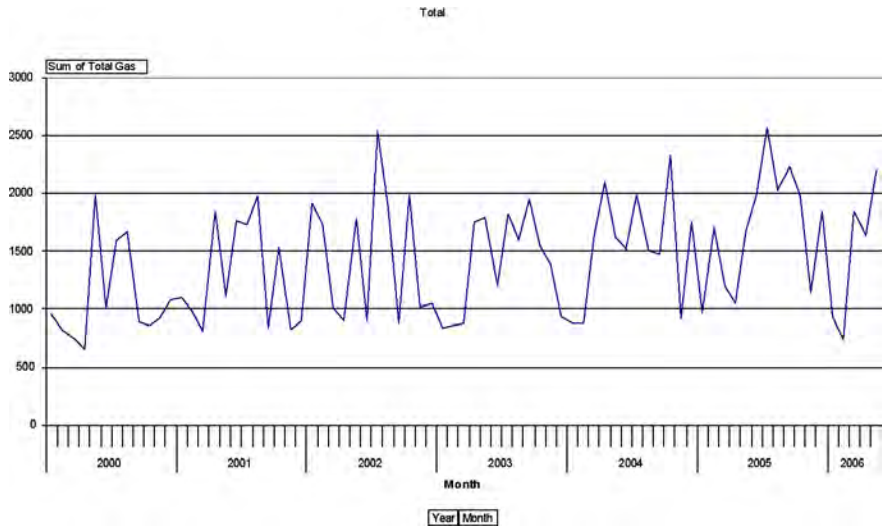
TRANSPORT FUEL

Some LPG is used for motor vehicle transport, and with the increases in petrol prices, demand for LPG fuel is continuing to grow. There is currently a several month waiting list in Dunedin for LPG conversions, and both Holden and Ford offer new LPG vehicles – either as dual fuel, or dedicated LPG only. In the Dunedin area there are about 30 fuel stations offering LPG for automotive use. Most of these LPG equipped service stations also refill the smaller sized gas bottles for portable heaters etc. Typically, each service station holds about 5 m^3 of LPG on site

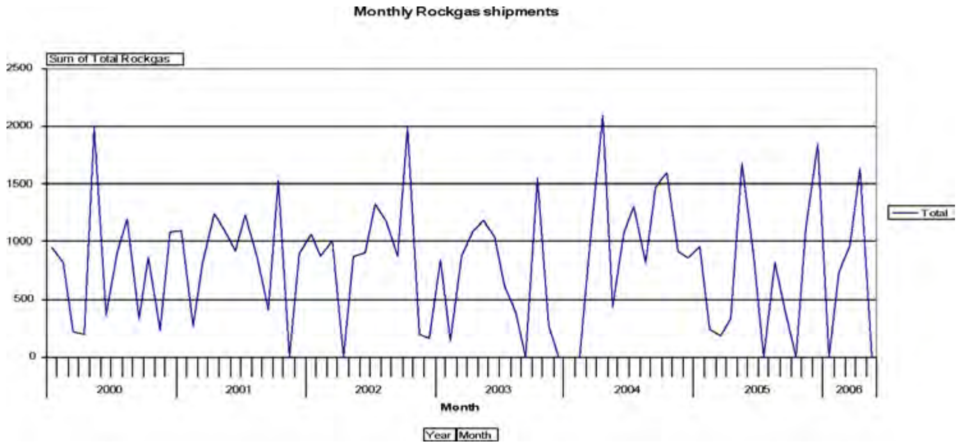
CURRENT CAPACITY

The reserve capacity of the bulk storage supporting the various reticulated gas systems

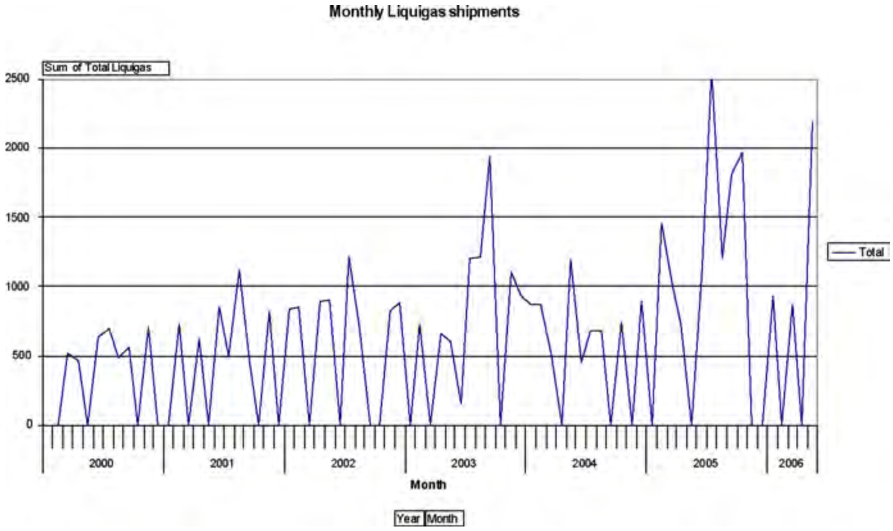
RockGas and Citigas (Novogas Storage Tanks at Hillside Road Facility



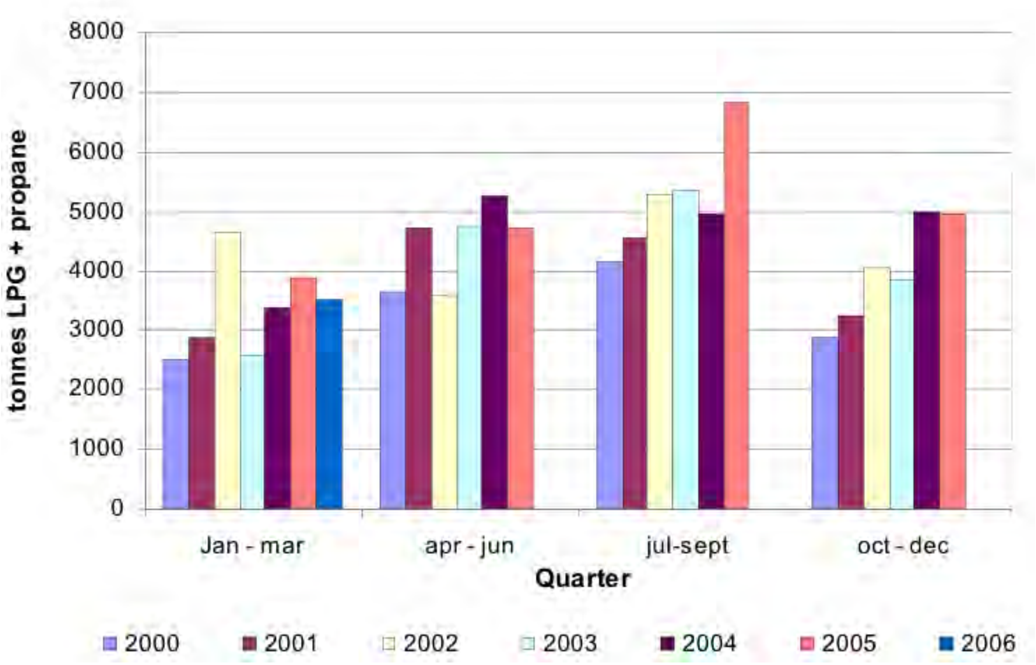
Total monthly gas shipments into Dunedin



Total monthly Rockgas shipments into the Liquigas terminal in Dunedin

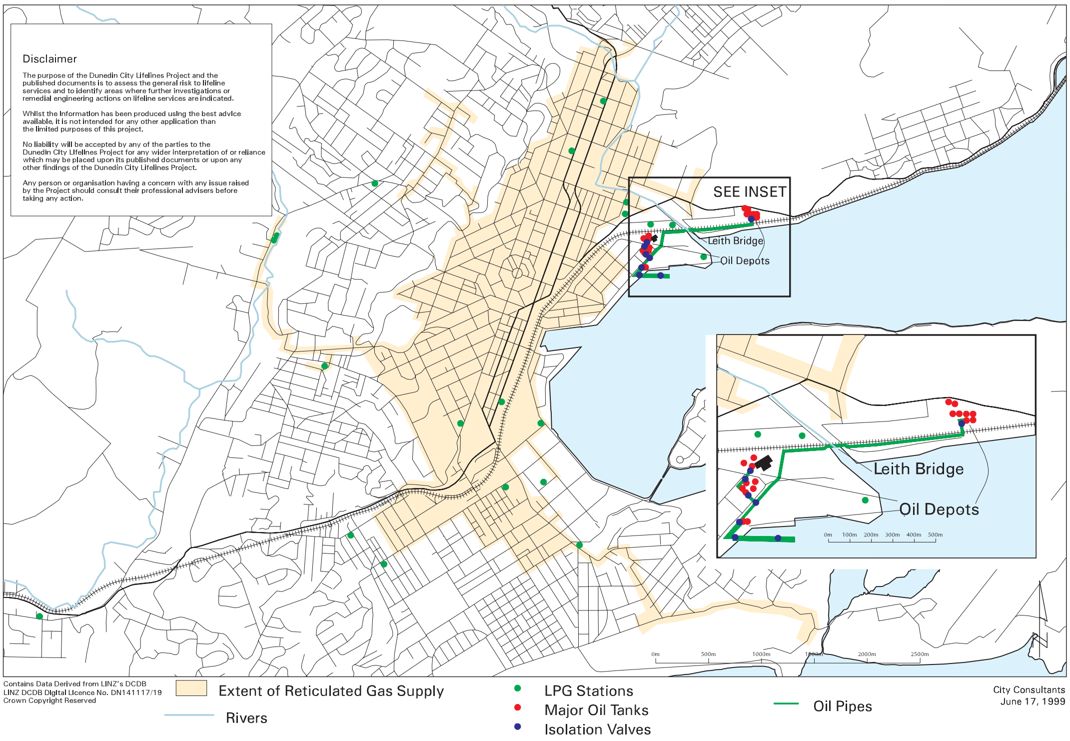


Total monthly Liquigas shipments into the Liquigas terminal in Dunedin



Total quarterly gas shipments into the Liquigas terminal in Dunedin. Includes both propane only and LPG (propane and butane mix) shipments.

throughout Otago is typically less than a week. Commonly, the cylinders are refilled every few days, especially in the winter. Whilst the Liquigas terminal has a couple of weeks of storage capacity, the delay time in getting ships down to Dunedin results in a spare capacity of only about two days. Therefore, should a ship supplying the Liquigas terminal be delayed longer than this time, the terminal would run out of gas, and the distributed storage cylinders throughout Otago would be depleted after a few more days. In total,



Disclaimer

The purpose of the Dunedin City Lifelines Project and the published documents is to assess the general risk to lifeline services and to identify areas where further investigations or remedial engineering actions on lifeline services are indicated.

Whilst the Information has been produced using the best advice available, it is not intended for any other application than the limited purposes of this project.

No liability will be accepted by any of the parties to the Dunedin City Lifelines Project for any wider interpretation of or reliance which may be placed upon its published documents or upon any other findings of the Dunedin City Lifelines Project.

Any person or organisation having a concern with any issue raised by the Project should consult their professional advisers before taking any action.

Petroleum and gas bulk storage in Dunedin

Otago has about one week's worth of storage capacity, after which gas shortages would occur if the bulk supply is not replenished.

5.3 COAL

Coal into the Otago Region is delivered predominantly by truck directly from the mine to major consumers. There is one major wholesaler of industrial grade coal in Dunedin (AJ Allen) and a number of smaller domestic oriented coal suppliers. A list of coal retailers is provided in Appendix 7.

The major coal consumer is the Meridian Energy owned Energy for Industries plant that supplies hot water for the Dunedin Hospital, Otago University, Laundry and Cadbury's confectionary. Other consumers of note are University accommodation complexes (University College, St Margaret's College and Arana Hall), Cerebos Greggs and PPCS, all in Dunedin.

The domestic market is supplied by bagged coal from Solid Energy, through various retailers, and bagged / bulk coal from the Kai Point mine. There is also some coal that is rail freighted through Otago – predominantly coal from the Solid Energy Ohai mine that is used at the Temuka Fonterra Plant in Canterbury. Solid Energy is phasing out domestic coal sales in the Otago / Southland region, and introducing a pellets as alternative heating fuel.

5.4 WOOD

Wood can be a low-cost resource or it can be very expensive: the major determinants of its utility as a fuel are supply availability and the type of appliance in which it is burned.

The species of wood consumed does not significantly affect the cost of operating a wood-burning appliance. Prices charged for a given fuelwood reflect its heat content.

Retail Supply

There are 19 reasonably large commercial firewood (Distributors) in Otago. In addition there are numerous small operators who supply firewood on an ad-hoc, cash-only basis. This wood could be sourced from land-use changes such as new subdivisions, scrub, aged shelterbelts, or small, semi-commercial groves.

Additionally, many firewood users, scavenge firewood from local forests, prunings, driftwood, or back paddocks. Such scavenging makes calculating total wood use from supply sources difficult and so any estimate needs to be cross checked against surveys of average wood use per user.

Appendix 7 Lists 19 Otago Firewood Suppliers. Actual volume has not been determined.

Storage Facilities

Firewood is sourced mainly from exotic forests. There are 19 commercial woodlots in Otago. The larger sources include:

- City Forests 15,600ha of plantation forest. These forests are located within a 70km radius of the city of Dunedin. Radiata pine makes up 87% of the planted forest area, with the majority of the balance being Douglas-fir and cypress varieties. The three main species include radiata pine (85%), Douglas-fir (10%) and macrocarpa (5%).
- Offcuts from sawn timber including Pine, Douglas Fir, Macrocarpa and Eucalypt species. Estimated volume around 6000 m^3 / year. Otago Chip Mill produces approximately 6000 m^3 / year which goes to Budget Price Firewood who transport offcuts to Christchurch, then back to New World in plastic bags as kindling. In addition they sell about 5000 m^3/year thrown firewood).

Pellets

Pellets are imported at present to the region with Solid Energy as the only supplier. The agent in Dunedin is now Wenita Forest Products Limited. See Section 5.5 for more details.

Distribution Systems

It costs between 15 - 20 cents to truck one solid m^3 of wood one km. As transport fuel costs rise, transporting fuelwood long distances will become increasingly uneconomic.

Capacities/reserves

Woodlot vendors endeavour to have 1-year of cut stock on hand and to turn over that stock on a yearly basis, as this suits the drying period which is approximately one year.

5.5 REGIONAL ENERGY PRICES AND PROJECTIONS

Energy Costs Otago

Energy costs in Otago are essentially pegged to national energy prices with small differentials for transport to the more remote areas. Local coal can be cheap as can local wood supplies especially if they are scavenged. Gas is not reticulated except in small community areas where LPG is piped to households from central tanks. In terms of what the future has in store for energy costs in Otago the difficult to predict energy sources are liquid fuels and gas as local prices are substantially linked to international prices, and thus subject to the vagaries of the international market.

Transport fuel prices

Transport fuel prices taken from the Energy Data File (EDF) from 1974 onwards are shown in figures below (the 2006 figures were added using weekly data from the MED). As can be seen, the real price (i.e. taking into account inflation using the CPI) data shows that 2006 prices are not yet close to those experienced during the oil crisis decade between 1975 and 1985. In terms of the future, however, it is thought that the volatility of international crude oil prices will be significant in terms of energy risk management for Otago. Any move to lessen the region's dependence on liquid fossil fuels will reduce that exposure.

Fuel oil for central heating

Minitankers of Dunedin gave the standard price for diesel as $1.22 ex GST per litre

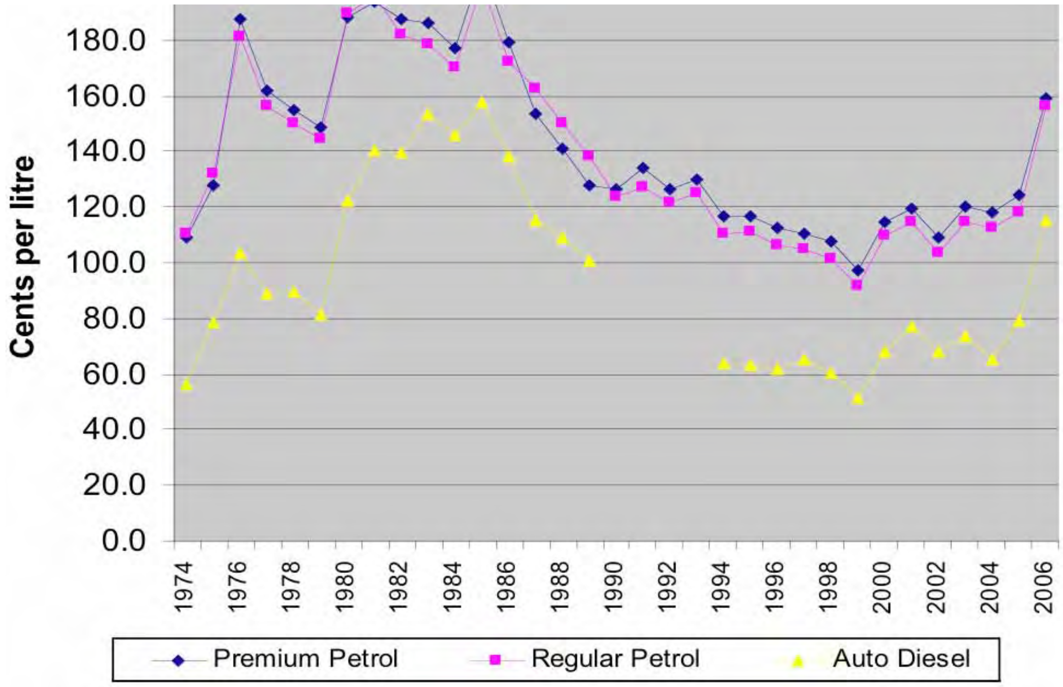
LPG prices

LPG prices for cylinders were surveyed from ROCKGAS depots in Otago. They show a little over 10% variation for different centres. Suppliers were reluctant to give individual contract pricing for commercial customers. The Dunedin price quoted below was for an Otago University hall of residence.

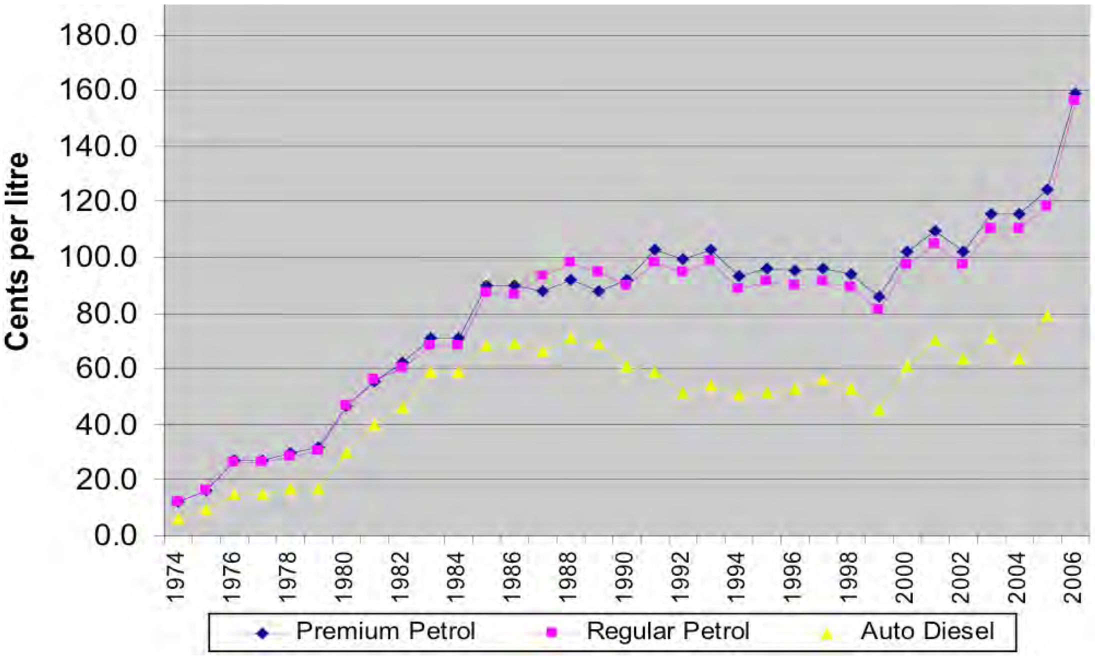
Dunedin	$1.78/kg residential and $1.67 commercial
Alexandra	$1.98- $2.16/kg
Wanaka	$1.92- $2.33/kg
Queenstown	$1.98/kg bottle and $39.03/ GJ ($1.93/kg) reticulated

In addition there is a quarterly rental of gas cylinders of around $33 (dual 45 kg)

Transport LPG is sold per litre. The EDF does not have data past 2002, possibly due to the difficulties of getting the information from the suppliers (suppliers were reluctant to give cost



Real transport fuel prices from 1974 (Energy Data File)



Nominal transport fuel prices from 1974 (Energy Data File)

information for this survey due to reasons of confidentiality).

As of 2002, the listed EDF price was 65c/litre which is equivalent to $1.21/kg (using a density of 0.534kg/litre as quoted for 60%/40% mix in the EDF). Thus the price of LPG might be surmised to have increased in nominal terms by around 47% in the 4 years from 2002.

Coal prices

Coal prices vary considerably depending on the coal quality. Green Island Coal in Dunedin sells lignite for $7.50 per 40 kg bag or 18.75c/kg. Woodland products in Dunedin sells Newvale Nuts (lignite) for $6.00 per bag and Ohai coal for $16.80 per 40 kg bag.

COAL PRICES at the mine *All prices are per tonne collected from the Kai Point Coal Mine at Kaitangata as at 1 December 2005, inclusive of GST*	
Household	$64 (50 – 200 mm)
Nuts	$64 (25 – 35 mm)
Peas	$64 (7 – 25 mm)
Chip	$50 (4 -10 mm)
Fines	$21 (0- 4 mm)
Dross	$50 (0 – 35 mm)

Coal Prices at the mine

Wood prices

Wood prices in Otago vary between $36 to $78 / loose stacked cubic metre depending on species and level of dryness. The cheaper prices are for green pine and the more expensive for dry blue gum. In addition wood can be scavenged for transport retrieval costs only.

Wood Pellets

A quick survey of retailers showed the cost of one Natures Flame 20kg bag of pellets, as at 8 June 2006, is as follows:

Dunedin (Mega Mitre 10) $9.95

Invercargill (Mega Mitre 10) Don’t stock

Christchurch (Mitre 10 or directly from Natures Flame, Rolleston) $8.25

Oamaru, Timaru and Ashburton $9.20

Alexandra (Mitre 10) Don’t stock.

The bulk price per bag is $7.50 but door-to-door freight is charged on top of this (freight costs vary widely). Bulk is a minimum of 50 bags (1 tonne). Cost per bag, including freight, is:

Dunedin	$9.04
Invercargill	$10
Christchurch	$8.13
Alexandra	$11.18

Nelson	$10.12
Auckland	$8.95

Natures Flame spokesperson said an Alexandra resident organises a bulk load of 10 – 15 tonnes (in bags) for a group of Central residents. They estimate about 100 people in Central owned pellet fires.

	Price/unit	Units	Conversion	Units	Approximate Efficiency	Cost of energy c/MJ
Gas residential	180	c/kg	49.5	MJ/kg	100%	3.6
Electricity (resistive)	18.66	c/kWh	3.6	MJ/kWh	100%	5.2
Electricity (Heat Pump)	18.66	c/kWh	3.6	MJ/kWh	240%	2.2
Diesel	137	c/l	38	MJ/l	90%	4.0
Coal (ohai)	42	c/kg	23	MJ/kg	70%	2.6
Coal(lignite)	18	c/kg	14.6	MJ/kg	60%	2.1
Wood	20	c/kg	15	MJ/kg	60%	2.2
Pellets	50	c/kg	17	MJ/kg	90%	3.2

Energy cost for space heating comparison
(see Appendix 5 for a national comparison)

FUEL POVERTY

Households that need to spend more than 10% of their income on fuels to keep warm and to service an adequate lifestyle would be deemed in most developed countries to be disadvantaged[10].

A recent International Energy Agency (IEA) report[X4] suggested that: "By 1995 New Zealand had the lowest space heating intensity (measured as energy per square meter per degree day) of all the countries studied, even including Japan and was about half of Australian levels." The report continued: "It seems unlikely in practice that comfort levels are so low in New Zealand. Possible data problems with wood may partly explain this apparent discrepancy".

The data used are correct and comfort levels are indeed low. Residential energy use in New Zealand for 1995 was around 17 GJ/capita/annum compared to around 35 GJ/capita/annum in Australia, 30 GJ/capita/annum in Europe and 54 GJ/capita/annum in the US.

The low values for NZ residential energy use reflect low levels of space heating. Houses in NZ are 'energy efficient' in the respect that they use little energy, but are poorly heated.

In addition, with the population being mostly located in the north of the North Island, the national average does not reflect conditions in the south, which has considerably greater house heating needs. For example, Auckland has around 1,150 heating degree days compared to Christchurch at 2,400, Dunedin at 2,600 and Invercargill at 3,000 degree days (the base temperature used is 18˚C).

COMMMERCIAL ECONOMICS OF FUEL OPTIONS

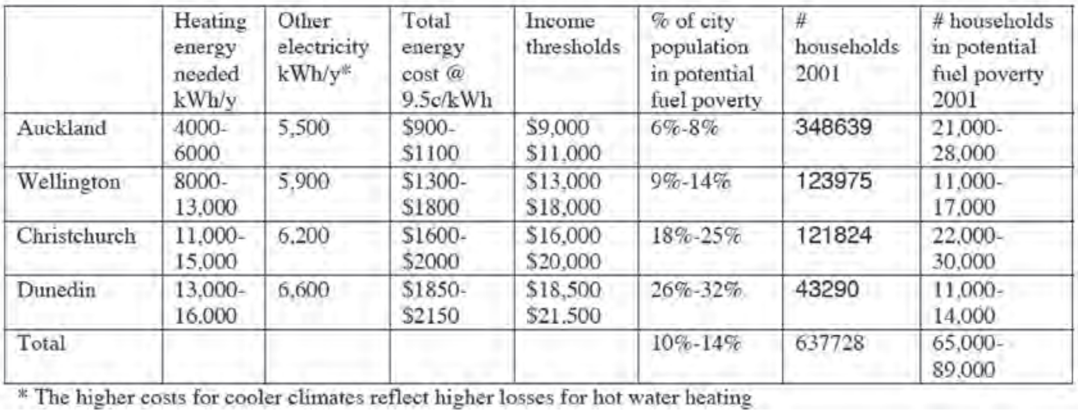
East Harbour[12] has undertaken analysis to give an indication of the relative economics for a range of energy sources. The two graphs opposite s show cost curves for electricity generation, curves for heat production (both of which include a $15/t carbon dioxide charge).

With the narrowing of the gap between fossil and renewable energy there may now be significant opportunities arising where renewable energy projects will be financially viable.

This may well be the case should the government decide to move to some form of carbon charge.

5.6 Electricity Pricing

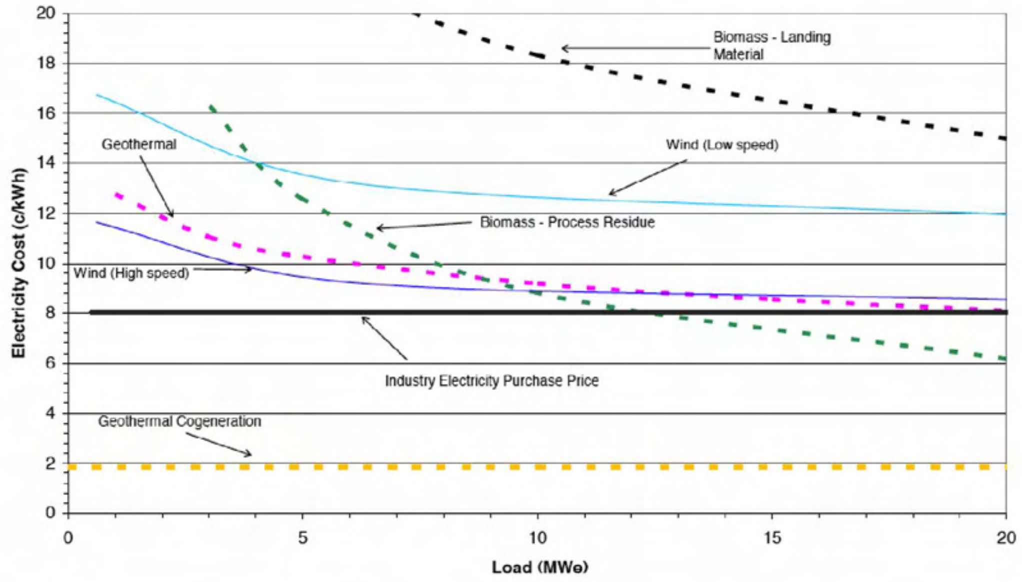
The following table provides a comparison of domestic electricity cost for a 8000kWh p.a. consumer. Fixed charges have been incorporated into the variable costs and the component of line company charges has been identified separately. The data is sourced from the Ministry of Economic Development's website.



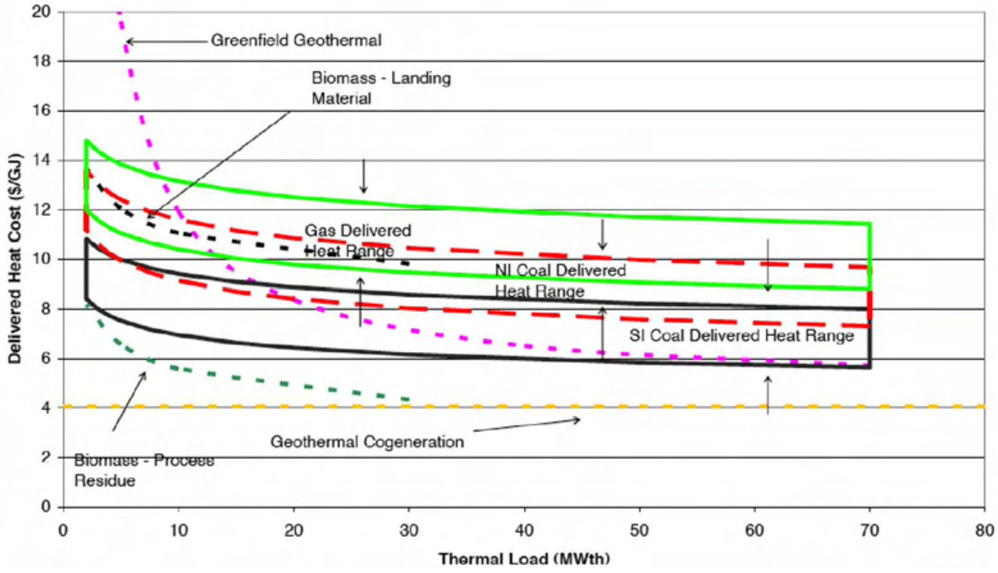
	Heating energy needed kWh/y	Other electricity kWh/y*	Total energy cost @ 9.5c/kWh	Income thresholds	% of city population in potential fuel poverty	# households 2001	# households in potential fuel poverty 2001
Auckland	4000-6000	5,500	$900-$1100	$9,000 $11,000	6%-8%	348639	21,000-28,000
Wellington	8000-13,000	5,900	$1300-$1800	$13,000 $18,000	9%-14%	123975	11,000-17,000
Christchurch	11,000-15,000	6,200	$1600-$2000	$16,000 $20,000	18%-25%	121824	22,000-30,000
Dunedin	13,000-16,000	6,600	$1850-$2150	$18,500 $21,500	26%-32%	43290	11,000-14,000
Total					10%-14%	637728	65,000-89,000

* The higher costs for cooler climates reflect higher losses for hot water heating

Fuel poverty for New Zealand households in 2001



Electricity production cost curves



Heat production cost curves

The following comments are made with respect the below data. They relate to an average domestic consumer:

- Nationally, over the past six years, line charges have increased 6% whereas total end user bills have increased 36%.
- Network Waitaki has the lowest line charges achieved via a non-commercial directive from its Trust to reverse an earlier price increase. North Otago, despite having the lowest line charges, does not have the lowest total charges. They are, however, lower than the national average.
- Dunedin has the lowest total charges for electrical energy and very competitive line charges. In all of Otago, Dunedin City consumers enjoy the lowest prices, best security, and highest reliability.
- Dunedin and North Otago enjoy lower total charges than South Canterbury and Southland.
- Central, East and South Otago has total pricing that exceeds the national average. These networks were sold by their historical owners to Aurora Energy Ltd and OtagoNet. The high prices paid are reflected in the high line charges needed to recover adequate returns.
- The charges in East/South Otago are now so high that the cost per kWh is at the strike rate for using diesel generation. Total charges are 22% higher than the national average and line charges are 25% higher than the national average.

Energy Price Path - Domestic Consumer Variabilised c/kWh for 800kWh p.a. Average

District	**Line Co**	**Retailer**	**15-Nov-99**	**15-Feb-06**	**Change**			
			c/kWh	**c/kWh**	**%**	**$**	**Energy Net**	**Var. to NZ**
NZ Total	Weighted Av		6.68	7.14	6.9%	$37		
		Incumbent	14.05	19.08	35.8%	$402	$365	
		Lowest	12.86	18.11	40.7%	$419	$382	
North Otago	NWL		8.68	5.64	-35.0%	-$243		-21.0%
		Meridian	15.13	17.39	15.0%	$181	$424	-8.9%
East/South Otago	ONL		5.75	8.92	55.0%	$254		24.9%
		Trustpower	13.48	22.12	64.0%	$691	$437	15.9%
Central Otago	DEL		7.16	8.68	21.0%	$121		21.6%
		Trustpower	13.41	20.46	53.0%	$564	$443	7.2%
Dunedin	DEL		5.84	5.80	-1.0%	-$3		-18.8%
		Contact	12.32	16.78	36.0%	$357	$360	-12.1%
South Canterbury	Alpine		5.93	6.40	8.0%	$38		-10.4%
		Contact	12.74	17.55	38.0%	$385	$347	-8.0%
Southland	TPC		6.26	7.31	17.0%	$84		2.4%
		Contact	13.76	19.99	45.0%	$498	$414	4.8%
	EIL		6.11	6.82	12.0%	$57		-4.5%
		Contact	12.93	18.64	44.0%	$457	$400	-2.3%

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Wood and Coal Merchants in the Telecom Yellow Pages, as of 16 June 2006

6 ELECTRICITY SUPPLY INFRASTRUCTURE

This chapter looks in more detail at the supply characteristics for electricity services in the region.

Electricity is a derived, instantaneous energy transport medium with no real ability to be stored except as other feedstock energy forms, e.g. potential energy stored in lakes. Electrical energy is derived from a primary source such as hydro, wind or thermal, and converted into electricity (with subsequent losses) that can be transported over long distances (with reasonably low line losses) and with negligible time lag to a load source.

It can also be said that most other supply chains are dependent on electricity for on-going operation. For example, the dispensing of liquid fuels cannot happen in service stations without electricity. The interconnectiveness of critical energy supply chains, specifically electricity and liquid fuels is a weak point in their security. This interconnectivness is aptly illustrated in the network diagrams presented in Appendix 1.

6.1 LOAD PROFILES AND DEMAND PROJECTIONS

Load Growth Trends

When considering load growth, we need to decide on the areas where load growth is most likely to take place. Based on the EDF figures, load growth in terms of domestic load growth per consumer has been constant since the mid 1970s and so growth will only occur if population expands which it is not doing in most of Otago. Thus growth will be in the commercial and industrial sectors, with the former being probably the largest component in Otago in terms of baseload and peaking due to the low level of heavy industry in most areas.

Electricity demand load growth trends are described in section 4.3. Electricity supplied to the region has been described at transmission level, but more importantly load growth creates the following impacts at the distribution network level:

- Higher loads trigger network upgrades for capacity and security reasons that tend to be large and lumpy. When the load growth is too small to generate economic levels of return line companies have an incentive to put in place demand management opportunities or stretch existing capability, possibly compromising security of supply in the short term.
- New load consumes capacity currently being shared by existing users and causes a resulting degradation of their service. When load growth requires substantial upgrades deep into the network it becomes difficult to recover upgrade costs on a user pays basis. In this case the hurdle to new investment can become undesirable with existing consumers exposed to rising prices or increased connection costs that become a barrier to expansion.

At some point the optimum level of supply network development for a particular design approach may reach its limits. Reaching this limit may require significant revamp of the network configuration, standards relating to voltage and conductor size, sub-transmission support, etc. This upgrading is usually very expensive to effect and not directly associated with an increase in revenue. Even at low levels of growth this issue is likely to occur before assets reach the end of their economic life.

When growth is associated with a change in load demographics such as shifting load centres or different uses the existing network may not be able to meet the new service requirements. Again there is rarely an associated increase in revenue with these trends.

GXP load profiles can also change to the point where there is a less efficient use of assets and, therefore, changes cost structures and required investment in peak capacity.

The above issues encourage a shift to a “just-in-time” approach to network development as does regulatory efficiency pressures to reduce planning horizons to 10 years. The risks associated with consenting for traditional line type solutions are increasing. Margins on the adequacy of infrastructure excess capacity are reducing. This is an issue when local economic growth exceeds 2-3% because normal 10-year contingent capacity may be exceeded before investment payback is achieved.

This problem is of greatest issue in Central Otago. Load growth is high (Aurora is predicting load growth rates of 4.5% for the Cromwell GXP and 3.5% for the Frankton GXP), tourism and changing load demographics are demanding higher service levels. Non-line solutions, increased contingency provisions, and alternative energy options/infrastructures should be considered.

Strategic decisions in the interests of the regional economy will usually take second place to the broader interests of national infrastructure capacity. If there is no direction or incentive being provided at a regional level, then the existing industry planning environment cannot be relied on to deliver an optimal outcome at the local level.

Modernisation of Domestic Heating

There is a growing tendency for new houses to have heat pumps installed for space heating. Heat pumps are displacing other forms of non-electric heating. It is not known definitively if the move to heat pumps will increase consumption but the move to larger houses is likely to contribute to increasing energy demand.

A study is underway at the Wellington School of Medicine (Otago University) to see what effect replacing existing heating systems with heat pumps will make. In terms of security of supply the move to heat pumps, especially from solid fuel heaters, will lead to a greater dependency on the electric power supply system. In addition heat pumps may also contribute to summer peaking, especially in Central Otago where day temperatures get much higher than on the coast, as they can be applied to cooling as well. Finally space heating heat pumps are generally not load controlled.

Areas of central Otago with relatively high summer temperatures and holiday loads might expect to see a shift towards peak summer loads rather than the winter loads now experienced. Access to low-cost air conditioners via the major retailing firms can be expected to have the same impact as has been experienced overseas. For example, Gisborne City experienced a 3MW increase in peak load attributed air conditioning last summer.

There is also an increase in the use of instant gas hot water heating. This technology will decrease the load needed if it displaces existing resistive electric water heating but it will also reduce the system load control capability, thus reducing capacity utilisation. This will lead to load profiles becoming more peaky and less efficient, meaning capacity will have to be added to compensate for lost efficiency. Such appliances usually need electricity for control power meaning that in the event of a electricity supply outage there will be no hot water.

Another trend, being actively promoted by heating vendors and gas supply retailers, which will reduce residential house space heating security is the trend to use gas fired “look a like” log burners. The associated reduction in use of wood also reduces contingent fuel reserves that households would have traditionally held on site. The dependency on gas supply is being increased at the same time. Areas of Central Otago now have significant gas reticulation and bottle distribution servicing the instant heat demands of holidaymakers. Yet we do not see a commensurate increase in Dunedin depot storage capacities.

Large house central heating hot water radiator systems are becoming more common particularly in the newer large homes that are appearing in Central Otago which may establish opportunity for CHP systems. Until recently diesel has been the main competitor to gas systems.

Wood pellet burners are still new to market but gaining acceptance. They are lower cost to operate than gas or diesel appliances. There is a significant opportunity for medium sized commercial applications. Some of the appliances are made in Dunedin so local products would benefit from promotion. Otago also has significant forestry that can supply raw materials for fuel manufacture.

Farming

There is a trend in farming practices to become more electricity intensive with a shift towards dairy conversion and viticulture. This trend will make the sector more vulnerable to network supply disruption

Rural networks in some cases lack the capacity for the associated growth and are not designed to meet the increased service requirements. As a result, significant sub-transmission reinforcement has been triggered in most rural Otago networks.

Freezing works are demonstrating longer and longer seasons. This demand overlaps with irrigation and the dairy season to create high demands during the traditional autumn and spring shoulder periods. Irrigation is likely to eventually dominate as the main load and establish summer peaks on rural GXP's.

This trend is more accelerated where the GXP also supports a high element of holiday load. Otago's lakes and more recent coastal areas are now presenting significant holiday peak loads.

There are no significant dairy factories (with the exception of cheese making) in Otago. All milk must travel to Southland or South Canterbury. Dairy plants are becoming so large in New Zealand that there is now a significant risk associated with loss of processing capacity when there is a fault. Increasing transport costs must now be placing pressure on the need for a local plant in Otago closer to primary production and an export port.

Wine making in Otago will also soon reach the point of triggering large scale processing facilities as seen in other wine making regions.

In the long term, water supply for all applications is going to be an issue. This will almost certainly involve increased pumping from the Waitaki and Clutha rivers. Water pumping now represents 12.5% of electricity consumption in North Otago and continues to be the main driver of growth. This consumption will double over the next 10 years.

Tourism

Tourism activity continues to grow in Central Otago. Centres that were once orientated at domestic holidaymaking have become full international resort centres with associated expectations on service and power supply performance.

Electricity demand in Central Otago is double that of North, South, and East Otago combined and is forecast to increase by 40MW over the next 10 years. Significant sub-transmission and interconnection capacity will need to be added. More distributed generation will be needed to secure supplies.

The development of coastal communities within commuting distance from Dunedin has been rapid over the past 5 years. There is continuing pressure to sub-divide coastal properties. These communities are generally at the ends of rural feeders with associated challenges to economic supply.

Aurora reports, however, that in Central Otago growth has not presented a shift away from winter peaking. The proportion of holiday homes and their low utilisation is remaining relatively constant. This seems at odds with the demographic trends where we see an increasing permanent population to service visitor numbers. This requires further clarification.

Industrial Scale Connections

Lead times for upgrading network capacity are typically in the 2-5 year timeframe and 8-12 years for larger transmission and generation projects. Development times for new large loads are typically in the 1.5-3 year timeframe. Developers tend to keep quiet about their plans until they are at resource consent stage. A lag can therefore exist between demand and supply, which can be a hurdle to development.

To avoid this scenario networks need to consider maintaining contingency of excess capacity at key locations in addition to minimum short-term security requirements.

Typical loads are:

- A large industrial plant (e.g. timber processing) may use in order of 10-15MW.
- A smaller industrial plant (e.g. an abattoir) in the order of 5MW.
- A large commercial development (e.g. a shopping mall) in the order of 3MW.
- A single commercial development (e.g. a supermarket) in the order of 500kW.
- A dairy shed with irrigation 200kW.

The addition of excess capacity to network development plans in order to trigger early upgrade would reduce risk of inadequate supply and support economic development. Power consumers carry the risk of developments not proceeding as early as envisaged due to constraints.

The following large new loads in the pipeline have been identified in Otago:

- A 25 MW irrigation scheme in North Otago. Stage 1 of 2 completed.
- A 17MW Cement Works in North Otago (at the planning stage).
- Expansion of the Macreas Goldmine.
- A mall in Dunedin.
- A prison at Milton and an industrial subdivision.

6.2 NETWORK CAPABILITIES AND CONSTRAINTS

TRANSMISSION

The Roxburgh Dam still remains capable of serving the Regions electricity demand. The 220kV transmission line, built to service the failed-to-materialise Araemoana Smelter will continue to meet all of Dunedin's transmission capacity in the foreseeable future.

This situation is reflected in Transpower's Annual Regional Plan (APR) 2006. Very few upgrades are planned and these tend to be of a minor nature such as transformer capacity upgrades. The following table summaries Transpower's planned responses to transmission issues in the region.

Section No	Issue	Solution	Indicative Implementation Date	Indicative Cost $M	Project Type	Status
18.5.1	Overloading of a Frankton supply transformer	Install third supply transformer	2007	4.0	Customer Specific	Provisional
18.5.2	Overloading of an Invercargill supply transformer	Supply transformer replacement	2008	6.8	Customer Specific	Committed
18.5.3	Overloading of a Naseby supply transformer	Install fans and pumps on the existing transformers	N/A	0.1 – 0.2	Customer Specific	Provisional
18.5.4	Overloading of a 220/110 kV interconnecting transformer at Invercargill	New 220 kV interconnection at Gore	2009	8.0	Reliability	Provisional
18.5.5	Overloading of a Cromwell supply transformer	New 220/110/33 kV transformer at Cromwell	2010	5.0	Customer Specific	Provisional
18.5.6	Overloading of a Halfway Bush supply transformer	Issue can be managed operationally; no investment required at this stage	N/A	N/A	Customer Specific	Information
18.5.7	Overloading of a Gore supply transformer	Issue can be managed operationally; no investment required at this stage	N/A	N/A	Customer Specific	Information

Notes:

- Except for committed projects, the indicative implementation date reflects the earliest opportunity for the issue to be resolved.
- Actual commissioning dates for customer specific investments would be subject to agreement with the local lines company.
- Costs for committed and proposed projects are the costs as submitted to the Electricity Commission.

Otago-Southland region transmission issues identified by Transpower

However, the APR needs to be viewed in light of the following limitations:

- Strategic issues at regional economy level are below Transpower's planning radar with respect to the core grid. Their focus is on total system performance not maximising regional advantages.
- Transpower's load growth forecasting assumes a steady state with regard to economic development and load demographics. That is, it only takes account of known annualised events and is limited to the extent that it is able to forecast changes like changing land use, energy policy, new technology, etc.
- Transpower has a conservative view that reflects the regulated nature of its business. It assumes responsibility for generation security and therefore develops solutions that are characterised by a high level of redundancy which can be economically inefficient.
- Overseas trends are to develop a network orientated at interconnection that seeks to manage unfirm generation via diversity. This approach enables the supply to minimise capacity to that needed for balancing and thus allows lower cost unfirm generation opportunities to be exploited. In NZ we are still far from this overseas scenario.
- As a regulated business, only transmission orientated solutions are considered and proposed. In the absence of input from external interests (particularly those who are not their customers) there is a lack of alternatives for them to consider or rely on in the planning of development strategies.
- In particular, externalities (such as climate change) are not considered and thus there is a lack of integration with broader energy supply options.
- Security issues are also only considered as far down the system as transmission (to GXP connection) and not in a more holistic light. Security standards are usually applied at a national level and not tailored to specific regional issues.

Transmission Upgrade Issues

The following load forecasts are taken primarily from Transpower's Annual Planning Report 2006. Note that there is a higher level of load diversity at GXP, meaning that disaggregated

Transpower GXP Demand Forecast							
District	**GXP**	**Line Co**	**2006 MW**	**2016 MW**	**% Growth p.a.**	**Security**	**Peak**
North Otago							
	Waitaki	NWL	5	6.5	3.00%	n	Summer
	Black Pt	NWL	11	22	10.00%	n	Summer
	Oamaru	NWL	31	35	1.29%	n-1	Summer
	Total		**47**	**63.5**	**3.51%**		
East Otago							
	Palmerston	ONL/OJV	6	7	1.67%	n	Winter
	Total		**6**	**7**	**1.67%**		
Central Otago							
	Naseby	ONL/OJV	28	34	2.14%	n	Winter
	Frankton	DEL	43	58	3.49%	n	Winter
	Cromwell	DEL	21	29	3.81%	n-1	Winter
	Clyde	DEL	7	15	11.43%	n	Winter
	Total		**99**	**136**	**3.74%**		
South Otago							
	Balclutha	ONL/OJV	27	31	1.48%	n-1	Winter
	Total		**27**	**31**	**1.48%**		
Dunedin							
	HWB-1	DEL	48	60	2.50%	n	Winter
	HWB-2	DEL	48	60	2.50%	n	Winter
	South Dunedin	DEL	68	85	2.50%	n-1	Winter
	Total		**164**	**205**	**2.50%**		

Transpower GXP demand forecast for Otago growth at local sub-transmission level can be expected to be higher. This is confirmed after review of the region's three network company Asset Management Plans.

Transpower's APR load growth forecasts can be interpreted as follows:

- In areas where growth is driven by development in the Primary Sector (farming) the 10 year average growth rate in terms of electricity demand is approximately 1.5% pa. This is seen in Oamaru, Palmerston, Balclutha, and their surrounding areas.
- In areas where growth is driven by development in the Secondary Sector (manufacturing and commerce) the 10 year average growth rate in terms of electricity demand is approximately 2.5% pa. This is seen in Dunedin.
- In areas where growth is driven by development in the Tertiary Sector (tourism) the 10 year average growth rate in terms of electricity demand is approximately 4% pa. This is seen in Queenstown, Wanaka, and their surrounding areas.

The transmission system into Dunedin, being well interconnected at 220kV, has no issues in the 10 year planning horizon with line capacity or security. Further there is sufficient capability to support the connection of a very large new block of load in Dunedin i.e. transmission line capacity presents no hurdles to large scale development.

In general the 110kV transmission system conforms to an older design standard and is stretched in terms of capacity for security and capacity for growth when demand gets into the 30-40MW range. It starts to have serious normal running capacity issues when load gets over 40MW. Options for propping it up run out at approximately 50MW.

There is, however, more of an issue for supporting load during contingent events in Southland.

Both Oamaru and Balclutha have GXP peak demands over 30MW. If a large load, such as the 17MW cement plant proposal for Oamaru eventuates, then transmission upgrade becomes a hurdle to development. This would be relieved by interconnection to the 220kV system which passes through these districts. Palmerston, and the development at Macraes Gold Mine (fed from Naseby GXP) has a similar issue with the exception that the 110kV is dedicated to Palmerston so increasing load to the maximum potential of the 110kV line doesn't place constraints on other GXP's sharing the line. The 66kV supply to the Mine from Naseby through Ranfurly does place future constraints on the capacity of the Naseby and Ranfurly transformers to supply more load to the local network. This is discussed further in the section on OtagoNet security of supply.

The current planning process and transmission pricing methodology has the following implications:

- The existing 110kV system copes with low levels of base load growth through a series of relatively low cost incremental upgrades of the weakest link i.e. is able to have is capability stretched and extended easily.
- The outcome is tighter constraints and reduced levels of excess capacity for large new loads without major upgrade costs. These hurdles are often sufficient to exclude consideration of a particular location for a development proposal. The distribution system is basically quite thin so developers will have to invest in major network upgrades.

Recent large scale irrigation projects in North Otago have resulted in the need to establish new GXP's and further developments will soon be constrained by the capacity of the 110kV lines which are shared by South Canterbury.

New load is connected on a "first come" basis. There is no entitlement to capacity other than the peak demand contracted for. Consuming capacity reduces the development and security contingencies for existing users. New loads often cannot support high levels of contingent capacity or security standards. Their connection results in degradation of the security other supplies. Consumers can find themselves in a "straw that broke the camel's back" scenario with regard to transmission upgrade costs.

Irrigation development in North Otago is an example of this problem. The economics of irrigation cannot support "n-1" security and this level of security is not critical for operational requirements. However, a fault on the irrigation supply, which shares the lines supplying Oamaru, creates the first contingency event seen by the Oamaru GXP. Further the consumption of capacity on the 110kV line has left insufficient capacity for the development of the proposed Cement Plant project.

The issue is: at what point and who will make the decision for a system wide migration from the old 110kV system supplying regional load to the 220kV standard of the core grid? No single transmission user is likely to be able to support such an upgrade on the back of a particular project, yet development of the 110kV system is desirable to support regional supply. There is a potential strategic advantage to the Otago region in finding the right methodology that supports local development.

As has been previously outlined, the transmission system is most constrained in the Central Otago area where growth rates are high. The original infrastructure development was intended for a much lower intensity of economic activity. Apart from the size of the load now needing to be supported, service level requirements (such as security), are different and more demanding for the tourism industry and holiday markers.

Traditional approaches to transmission security such as carrying full redundancy in terms of asset investment may no longer be appropriate for the following reasons:

- 100% redundancy is expensive and difficult to justify on a security only basis. Costs of upgrade are also difficult to pass through to existing users who have different dependencies and ability to carry the costs in their businesses.
- The environmental sensitivity and impact on property values in areas like Queenstown makes options like the installation of an alternative transmission line very difficult to achieve. The transmission line into Frankton is a dual circuit single tower configuration. Tower lines on single towers are prone to conductor clashing and tower failure in heavy snow conditions. This does not provide a true n-1 level of security.
- The load centres are spur connected to the core grid. Security is only achieved as deep as the assets are duplicated, ie. to provide n-1 security
- Isolation due to weather events has a higher risk and frequency. Single line routes are vulnerable to weather disruption. The lack of interconnection makes for a weak system.

These areas might better be served by alternative strategies that include distributed generation for servicing local load, improved diversity of energy supply such as gas options with storage and the ability to fuel switch, as well as diesel gensets for securing critical loads such as a hotels.

This situation, as described, entails a shift from sole reliance on the traditional grid supplied model to distributed energy systems. In respect of the Otago region, where assets are 110kV and spur connected i.e. not part of the core grid, it is likely that local line companies will be able find lower cost solutions if they have the opportunity to invest in these services themselves.

The 110kV spur lines to Frankton and Palmerston, and some of the transformer upgrades (e.g. Naseby), are targets for lower transmission charges either through acquisition or by-pass.

Currently, Transpower feeds Palmerston via a dual 110kV line and single transformer. This is a n level security scenario. OtagoNet then returns the power via a single 33kV subtransmission line as far back as Waitati. An intermediate 110kV substation/GXP would allow that substation to support the Palmerston sub via a tie circuit (redeployed 33kV line) thereby improving security.

This strategy uses distributed capacity across multiple off-takes and uses existing assets to provide a higher level of interconnection.

Regional Collaboration

The different commercial imperatives across the three lines companies also presents its own issues with regards to rationalisation of the region’s electricity infrastructure.

Network Waitaki (NWL) is 100% owned by a consumer trust and has a 50% shareholding in NetCon Ltd (a line contracting company). NetCon is also 50% owned by Alpine Energy

Ltd (the South Canterbury line company). NWL is headquartered in Oamaru, NetCon is headquartered in Timaru with a smaller office in Oamaru. Network Waitaki and Alpine were being managed by a joint venture company, Networks South Ltd from 1999 to 2005. This relationship was terminated when NWL decided local interests were best served by a local engineering and management team as the company entered a period of more intensive network development.

NWL has no debt and targets low profit margins, discounting surplus earnings back to consumers. Its ability to service debt is limited without overcoming pricing control. Being a consumer trust owned company limits its scope for community, as distinct from consumer, orientated new investments as it must demonstrate that the benefits are being delivered to consumers.

Aurora Energy Ltd is owned by the Dunedin City Council. It's assets are managed and operated by its subsidiary company Delta Utility Services Ltd. Dunedin City has sold its other energy and infrastructure company interests such as City Gas. Delta has broadened its services beyond the electrical industry to include a major focus on roading and council asset servicing. These services extend well outside the Otago Region. This is a response to limited opportunity to acquire the other electricity assets within the region. Aurora is, however, the owner of the line assets of the former Central Electric company. It was outbid by Southland interests for the Otago Power network and has not been able to overcome local interests in North Otago.

Aurora conforms to a conventional commercial model (short of full privatisation) with its owner maintaining an arms length involvement. Sole ownership by DCC results in a district perception that the company operates in the interests of Dunedin.

OtagoNet is an asset managing/operating joint venture between the Southland power line asset management/operating company PowerNet and Marlborough Lines (a conventional line company headquartered in Blenheim). PowerNet is in turn owned by the Southland line companies, The Power Company and Electricity Invercargill.

PowerNet is more limited in scope than Delta, for example, with no in-house contracting capability or expansion beyond the electricity industry. This limited opportunity for expansion underlies the very competitive bidding made against Aurora in the acquisition of Otago Power's line assets. The sale proceeds from Otago Power have been distributed to its consumers via its consumer trust ownership.

OtagoNet conforms to a conventional commercial model sharing profits with its Southland and Marlborough owner. The company is debt loaded and capital constrained (the winners curse) with the inevitable consequence of price increase pressure.

A further ownership complication is that PowerNet's owners also own between them a 50% share of a line contracting company called Current Connectors Ltd. NetCon, the line contracting company owned by Network Waitaki and Alpine Energy is the other 50% shareholder. Contracting resources outside those controlled by Dunedin are therefore dominated by Southland and South Canterbury interests. This has implications for priority access during emergency event response.

In short the probability of achieving an integrated single approach to distribution assets at regional level is as likely as achieving a single unitary authority. At an operational level line companies are able to work together in the interests of common good so this is not a hurdle to a coordinated regional energy strategy.

Line Function Services

In general, the Otago Region is well served by its line companies in terms of having a low outage performance and cost relative to national averages despite low load density and challenging terrain in significant areas. In some quarters high reliability is seen as an indication of over investment and this receives close scrutiny from the Commerce Commission.

In Otago reliability is more likely related to the need for more robust design standards to cope with the weather extremes assets are exposed to. At a national level other line companies are pursuing strategies to at least match Otago's performance.

The performance details of lines companies is published in their Asset Management Plans which are a Commerce Commission disclosure requirement. These Plans are available on the lines companies' websites and have been reviewed for relevant information important for this report. Extracts from these documents are presented in Appendix 6.

Performance however is not consistent between districts within Otago and is a legacy of the different starting positions pre-reforms. At a national level outage performance has improved by approximately 9%. For this study outage performance has between analysed by comparing the SAIDI indices disclosed by lone companies.

SAIDI (System Average Interruption Duration Index), is the number of minutes per annum that a consumer connected to network can expect to be without power. The national average is approximately 2.5 hours per year usually spread over 1.5 events.

Network Waitaki has traditionally maintained a best performer position i.e. high service for low cost, for an average density rural network. This performance has been based on quality of design/engineering and live line maintenance practices. Network growth related development is currently stretching outage (not reliability) performance. Key comments regarding NWL's outage performance over the past six years are:

- Unplanned outages (faults) for a rural line company continue to be very low reflecting good network condition and design. Faults have decreased over the past six years.
- Planned shutdowns have however increased greatly over the past six years resulting in a total performance that has been 64% poorer than the 1999 position. This situation is believed to a result of the previous joint venture change of work practice away from reliance on the "live line" techniques (that NWL is an industry leader in) and a response to irrigation driven growth that focused on line upgrade instead of sub-transmission support. Now that NWL once again has operational control of its network a reduction in planned outages might be expected.
- North Otago's outage performance remain better than the national average by about 40%.

Aurora energy Ltd is the New Zealand leader in outage performance for city networks. The addition of Central Electric network, which is moving rapidly towards the characteristics of a high density rural network, reduces outage performance to a figure of approximately 80 minutes per consumer per year. This is still a much better performance than the national average. The situation in Central Otago has been improving with the network reinforcement associated with high growth i.e. service related

District	Line Co	SAIDI 1999			SAIDI 2005			Improvement	
		Total	Planned	Unplanned	Total	Planned	Unplanned	%	Mins
NZ Total	Average	160			145			9%	15
North Otago	NWL	64	13	51	105	61	44	-64%	-41
East/South Otago	ONL	341	184	291	174	76	98	49%	167
Central Otago	CEL/DEL	203			150	30	120	26%	53
Dunedin	DEL	51	3	48	51	3	48	0%	0
Dunedin & Central	DEL				80	7	73		
Estimated figures									

System Average Interruption Duration Index for Otago lines companies investment is keeping pace with load growth.

Information about Central Otago performance when considered independently of Dunedin City is a little scarce. However the following conclusions are made:

- Outage performance is close to the national average.
- It has improved approximately 25% since Aurora's purchase of the network from Central Electric i.e. CEL performance was worse than average. This improvement is 2.5 times the rate change in the national position.
- Growth in area helps with improving reliability as old assets and designs are replaced.
- The low level of planned outages is a reflection of Aurora's leadership in the use 'live line" work practices.

Aurora is also a national leader in quantifying the value of investment made to avoid outages and to discover the associated economic opportunities. This leadership is achieved by using the probabilistic analysis approach and applying a value to the cost per kWh of unserved energy. Aurora uses a value of $4/kWh for domestic load and assumes a relatively high default value of $40/kWh for unplanned commercial load in the absence of an agreed alternative by consumers. CAE has calculated a national figure of $17/kWh for the Electricity Commission as a benchmark for transmission investment. This study has reassessed the value specifically for Otago. A caution is needed, however, in the application of this benchmark, which is discussed in Section 6.4.

Both security investment and performance payments are related to the security standards applied by a line company. These vary between networks and are discussed below.

OtagoNet has come from a position of low cost and low service. It also has the disadvantage of being one of the lowest density rural networks and so has had a legacy of uneconomic supply conditions.

For the past decade it has been pursuing a strategy of asset renewal with a corresponding 49% improvement in performance. Performance is however still below the average i.e. a higher level of outage. Half of this can be attributed to planned outages and upgrade work intended to improve the situation. Performance is comparable with their Southland neighbour The Power Company which is managed also by OtagoNet's parent company PowerNet.

OtagoNet has the highest level of outage in the region resulting from planned shutdowns. This situation is considered to be the result of renewal programmes being focused on line replacement and the low consumer density with its corresponding lack of interconnection/ security investment.

DISTRIBUTION UPGRADE ISSUES

Network Waitaki Ltd

Capacity utilisation reflects the amount of irrigation load that is developing on the network. Transformers need extra capacity for pump starting duty. Benchmarks are typical compared to networks with similar load demographics.

NWL's load factor is very high for a rural network (70%). This high load factor is the result of increasing intensity in farming practice enabled by irrigation. Irrigation has essentially filled in the off peak demand profile delivering a more efficient system load.

The network has reached the limits of its design assumptions and excess capacity. With increased load and changing load demographics, significant network reconfiguration and development is required in the medium term to service changing service requirements. NWL has responded by greatly increasing its focus on planning via the production of a formal Network Development Plan which considers several issues including:

- Continue to develop the 33kV sub-transmission system as the backbone of the network.
- Compliance with NWL design and security standards is based on the EEA Guidelines for Security of Supply in New Zealand Electricity Networks – June 2000. Fault restoration targets are also based on the EEA Guidelines, Appendix 6.
- The network backbone is approaching the limits of its original contingent capacity.

NWL purchased 3 x 635kVA mobile diesel generating sets in 2005.

- Note: Project Aqua has not proceeded but the associated Irrigation Scheme currently in development was commissioned in May 2006. This 20MW Project is supplied via a new 110kV GXP provided by Transpower at Black Point via a Notional Embedding Agreement in lieu of a 66kV interconnection with Lake Waitaki. The short 110kV line from Black Point to the Irrigation Scheme was one of several lines in the region to have suffered damage during the recent snow storm in the South Island. NWL considers it uneconomic to provide extra resources for rare events, such as this snow storm.
- Increase the quantity and number of zone transformers such that there is sufficient excess capacity remaining in other substations, able to be redeployed, in the event of major transformer fault. The primary purpose of some transformers will therefore be as strategic spares even though they may be in service and share a burden of normal loading conditions.
- Distribute zone substation capacity via an increase in substation density such that a zone substation can be removed from service and its load supported by the excess capacity of its neighbours. This tactic limits the effect of load growth being concentrated at existing zones and triggering higher Security Standards. Keeping load distributed localizes the impact of outages and reduces the cost and capacity of backup provisions.
- Develop a configuration at urban zone substations that is able to be readily configured to an “n-1” security standard.
- Develop ring formations in the 33kV sub transmission system.

Aurora

A summary of items from the latest Asset Management Plan for 2006-2016 related to future energy supplies in the region describes a number of issues, including:

- Upgrades to 33kV sub-transmission system where constraints are predicted to develop.
- New projects or extensions are considered in detail but only proceed if revenue security is obtained
- An external risk review is planned for 2006/7 focusing on reliability issues. (“During the flash floods in Dunedin in early February 2005, five underground distribution substations were flooded. Remedial work should be completed over the next three years”)
- Frankton does not yet have n-1 security while Halfway Bush does not have n-1 security unless there is significant Waipori generation. Long term plans have been made to address these issues.
- The environmental risk from accidental discharge of insulating oil into waterways has been covered through transformer oil containment facilities at all locations where oil quantity exceeds 1000 litres. Oil spill kits are also provided.
- The Dunedin emergency generator was replaced in September 2005.
- Potential installation of diesel generation in Cadrona vs constructing new line is being considered.
- Contact Energy proposes to install 16MW of hydro generation at Lake Hawea but has yet to obtain resource consent. If this project proceeds, a 33kV line will be needed from Maungawera to Hawea (6km) and the existing 33kV cable and line between Wanaka and Maungawera will require upgrading.
- Pioneer Generation is investigating installing a 40MW hydro generation station on the Nevis River and it has enquired about options for connecting this generation to the Aurora network. The Aurora network cannot accommodate the generation without significant upgrading. Indicative costs have been given to Pioneer which also has the option of connecting to the nearby Transpower 110kV lines.
- Other major developments have been proposed by third parties. These, and possible consequential works, are not included within this document in order to protect third party commercial interests.

OtagoNet Ltd (OJV)

A summary of items from the latest Asset Management Plan for 2005-2015 related to future energy supplies in the region describe a number of issues including:

- Continue to develop the 33kV sub-transmission system to improve and meet security targets.

- Upgrade of 11kV distribution where constraints are predicted to develop.
- Upgrade of the Milton Zone substation (Dunedin Airport) and increase in supply to Macraes mine are being planned. Other towns for planned upgrades include Clydevale, Clinton, Owaka and Milburn. The Palmerston point of supply will also be considered in conjunction with the Macraes mine upgrade.
- There is little interconnection at subtransmission or distribution level between zone substations. This limits the ability to provide a n-1 security level of supply.
- In general users are satisfied with the overall levels of service. However concerns have been raised by farmers on the restoration sequence after loss of supply as dairy cows suffer if the milking process is stopped for long periods.
- The pricing constraints imposed by the Commerce Commission regulatory regime will prevent justification of some of the needed expansion projects. New projects must be economically viable to match network company requirements.
- The reliability of supply criteria (SAIDI etc.) are generally close to target with some feeders just over. Severe weather related events in 2003 and 2004 caused major interruptions. OJV has a service pledge of $25 if power is not restored in 6 hours for urban areas and within 16 hours for rural areas. There have been no payments to date as all breaches have been due to storms. In 2005 there were 9 justified voltage complaints which took an average of 49 days to remedy.
- Security standards are based on the EEA Guidelines and given in the AMP. There is one example of using on-site embedded generation for peak load reduction and two examples of remote area power schemes being considered due to the high cost of network extension.
- Because the network assets are spread over a wide area single events do not usually involve too many consumers. OJV aims to provide a good service by reducing system restoration times after faults. The System Control centre is manned on a 24/7 basis which also acts as the Emergency Response coordination centre. Contracts are in place with fault contractors on immediate standby.
- Amongst the highest risk factors identified on the network are the old 11kV switchgear panels and the network data records and storage facilities.

6.3 QUALITY OF ELECTRICITY SUPPLY ISSUES

A summary of the current security levels throughout the region is given in the table on the opposite page. As can be seen, there are significant parts of the region without n-1 security levels.

Security Standards

The Electricity Engineers Association (EEA) prepared a comprehensive set of Guidelines on behalf of the industry following the Auckland CBD power failure of 1998. The Guidelines were issued in June 2000 and describe levels of security of supply generally considered appropriate for electricity networks in New Zealand.

The Guide acknowledges that system planners or network managers will set their own levels or “standards” of security of supply applicable in their networks. Network companies are obliged to publish the agreed performance criteria and measures of supply to their consumers under the Electricity (Information Disclosure) Regulations in their annual Asset Management Plans or Network Performance Reports. These criteria are summarised as the SAIDI, SAIFI and CAIDI figures for the network and trends are easily established.

The EEA Guide also lists some exclusions where it is not intended the networks comply with the guidelines in certain circumstances such as:

- Emergency situations arising from extreme climatic conditions;
- Lack of availability of electrical energy for supply into the network;
- Lack of stability in the electricity system;
- Failure of the bulk electricity system to

	GXP	Substation	Capacity n-1	Security n-1
DEL (Aurora)	Halfway Bush	Halfway Bush	Y 2006	N
		Mosgiel	N 2006	Y
		Port Chalmers	Y to 2011	Y
		Smith Street	Y to 2013	Y
	South Dunedin	Corstorphine	Y	Y
		North City	Y	Y
		South City	Y	Y
	Frankton	Arrowtown	Y to 2010	Y
		Queenstown	Y	Y
		Frankton	Y to 2008	N
		Remarkables	N	N
		Coronet Peak	N	N
	Cromwell	Cromwell	Y to 2015	Y
		Queensbury	N	N
		Wanaka	Y	Y
		Maungawera	N	N
	Clyde	Roxburgh	N 2006	Y
		Alexandra	Y	Y
		Clyde	Y to 2011	N
OJV	Balclutha	Charlotte St	Y	Y
		Milton	N	N
		Mahinerangi	N	N
		Clydevale	N	N
		Clinton	N	N
		Owaka	N	N
	Palmerston	Palmerston	N	N
		Deepdell	N	N
		Merton	N	N
	Naseby	Macraes Mine	N	N
		Ranfurly	Y	N
		Paerau	N	N
		Hyde	N	N
		Middlemarch	N	N
NWL	Oamaru	Chelmer St	Y	Y
	Waitaki	Kurow	N	N
		Otematata	N	N
		Omarama	N 2006	N
		Ohau	N	N
		Ruataniwha	N	N
	Twizel	Twizel	N 2006	N

Current electricity security levels throughout the Otago region

maintain proper supply quality; and

- Short-term interruptions (less than 1 minute duration).

System planners are recommended to undertake a review of the above contingencies and provide an emergency response to ensure adequate preparedness for such events. The Guide also has useful descriptions of customer service, security and reliability of supply requirements.

The basic criterion applied is whether the supply satisfies the basic “n-1” test of redundancy in the supply chain. This means that if one major item of equipment fails the downstream supply will not be interrupted. Supplies to important load centres can be made more secure with a “n-2” criterion or “n-1” under maintenance outage conditions.

In the case of a major CBD the "n-1" criterion should be applied to the complete substation or main supply points. The recent Auckland power failure highlighted the lack of this criterion and steps are now being taken to provide a new completely separate main supply substation into the CBD.

Network companies adopt this "n-1" criterion in various ways and it is not always easy to determine if a supply point will indeed meet the criterion for any one item of equipment failure.

The traditional method of securing a network is achieved by duplicating assets with 100% redundancy and configuring these such that any single failure does not cause an outage and load is able to carried by the second set of assets. This is called n-1 level security. It only secures down into network as far as assets are duplicated and is a very costly and asset intensive approach for usually very low probability events.

This fact excludes its economic application to low load density networks, especially for networks where existing reliability is very high the investment needed for a n-1 upgrade is difficult to justify.

A more common approach is to concentrate on being able to isolate or by-pass faulty sections of line and re-liven the unfaulted part of the network. The assets that support this approach are those that:

- Allow quick identification of what has faulted.
- Minimise the area impacted by a fault.
- Provide options for restoring supply through interconnection and excess capacity on supporting assets.
- Automation of switching.

Security standards vary from line company to line company within the region. Industry level security standards usually only apply at loads that well exceed those experienced in rural networks. In general Otago line companies have set their own standards that are tighter than industry practice in New Zealand, i.e. higher security for smaller loads.

However application of these higher standards does not mean delivery of higher security because the load density is still well below that required to trigger a traditional redundancy type response.

Security standards are based on multiple criteria:

- The size of the load connected at a given point under consideration.
- The number of consumers impacted by a fault.
- The amount of demand that can be partial restored within defined time periods.
- The vulnerability of the key loads involved.
- The cost/risk tradeoff.

For example, Dunedin has an advantage of having loadings that justify n-1 security in its sub-transmission backbone. Load density has also supported historical high levels of interconnection at distribution voltages. Its lines are short and the system has a high percentage of underground lines. The system is thus less likely to capture faults from a wide area.

On Network Waitaki's network only the sub-transmission system supplying the Oamaru CBD has n-1 security and even then all 11kV feeders from that substation aren't n-1 configured and rely on interconnection for reducing restoration times.

The rural network is characterised by a large percentage of spur connection and therefore cannot be back fed via an interconnection following a fault. One third of the network is two-wire single phase, meaning that the upgrade cost to develop rings/interconnection is not an economic opportunity. This situation will become an issue as rural load demographics shift from sheep farming to dairy farming, the latter having different service requirements in terms of restoration times.

6.4 VALUE OF LOST LOAD

Introduction

CAE has prepared a model for assessing the cost to consumers of non supply or Value of Lost Load (VoLL). This model was developed for the Electricity Commission to apply to its assessment of the economic value of grid investment in reliability measures.

In this work, the model has been adapted to Otago by substituting the reliabilities of the local distribution networks and basing cost data on a survey of local businesses.

A survey was sent to the larger consumers on each network. Cost data has been derived from the 24 responses received. With more time the surveying could be more thoroughly completed however the averaging processes desensitises the model to these inaccuracies.

Comments on Input Data

Consumers have been allocated as Residential, Agricultural, Commercial, and Industrial based on annual kWh consumption and connection number/pricing disclosures. The following Otago comparisons with NZ averages are made:

- Residential load represents 37% in Otago compared to 34% in NZ. This minor difference is most likely the result of higher consumption in the colder climate. As consumption was assessed on the basis of the number of connections it is likely that this figure is understated.
- Agriculture demand at 13% is significantly higher than the national average of 4%. This corresponds with lower Industrial consumption and indicates that the Otago economy is still driven by the primary sector. Otago also lacks the sizable cities of other regions. Irrigation load has been included in this sector which makes up the bulk of the load at the large consumer end. Irrigation is not particularly sensitive to power outages as it can tolerates days without supply and is only used for a few months per year during low rainfall. Dairying, however, is very sensitive to power outages due the risk of losing milk because of failed chilling.
- At 35% in Otago compared to 22% for NZ the Commercial sector is also a higher proportion than the national average. Hospitals, schools, water, waste water, and civic buildings are included in this group and represent a high proportion of large users in the sector. The University of Otago figures highly as a load in Dunedin. In addition the sector includes hotels and other tourism facilities such as ski-fields.
- Industrial at 15% in Otago instead of the national 40% indicates that the region does not enjoy the benefits of loads in the Major User class. Dunedin tends to be a manufacturing and processing centre rather than an industrial centre. The large loads other than those mentioned above are the likes of freezing works, saw mills, etc.

Event duration probability was assessed for each line company and Transpower from disclosed five year targets and actual performance. Despite different line companies having a different probability distribution the impact on VoLL only varies from $12.72/kWh to 12.75/kWh. The main impact of longer duration outages having higher probabilities is the volume of unserved energy will be higher (all else being equal) and this will send a higher investment signal.

The survey results did not provide sufficient data to be able to assess the variance with time on costs for the Agriculture and Residential sectors. Accordingly the same cost distribution as derived for the Commercial sector was applied to the Agriculture sector. Data from CAE's 1992 survey was applied to the Residential sector. This sector will be conservatively low as households are more dependent on electricity, with IT equipment and working from home being more prevalent.

Comments on Result

Survey results did not show any indication of being influenced by the recent outages and the security debate occurring in Auckland currently. In fact the Otago VoLL of less than $13/kWh is significantly lower than the National VoLL of $17/kWh.

The lower VoLL reflects lack of high density cities and perhaps the greater resilience of a rural based economy. The probabilities of longer duration outages are lower than the national average and the nature of businesses such as farming are able to cope quite well with short duration outages.

The vulnerabilities that were highlighted by the VoLL survey are as follows:

- Supermarkets have a high loss potential due to frozen products, etc. and tend to depend on networks for their security. Their competitiveness with each other has not resulted in investment in contingencies i.e. they take a very short term view of risk. With regards to these businesses holding the regions emergency food supplies this is a civil defence issue. Insurance payouts do not feed people.

- Some larger more established locally headquartered businesses appear to be less up to date with the provision of their own security measures. Manufacturers and freezing works are the main businesses at issue. They rely on their importance as major employers to expect better service than other consumers.
- It appears that the lessons of events like Auckland CBD crisis have yet to be learnt. There is a limit to the security levels that potentially can be provided at network level. Internal installation security measures represent better returns on investment.

6.5 SUPPLY SIDE OPTIONS/UPGRADES

To be successful in niche energy retailing a company needs to have sufficient capacity and sufficient diversity to match the local load conditions. Currently, the only local option with a reasonable generation portfolio is Pioneer Generation. This company only generates and sells to energy retailers via the wholesale market.

Line companies remain the most likely developers of distributed generation because of their ability to deliver solutions to network issues, and their local presence allows management of these assets in an integrated fashion with their own network assets. Where regulation still remains a hurdle, there is a possibility for line companies to develop and then sell generation bundled with supporting management contracts.

Supply Side (Generation)

The fundamental consideration with generation as compared to transmission is that it adds electric power supply into the system whereas transmission just distributes it. Generation can also create economic value from local resources, whereas transmission tends to be a cost. Generation is a high value opportunity for the Otago Region. The region has more opportunity than it needs for its own purposes. Exploiting its under-developed resources can be a strategy for increasing the economic well-being and resilience of its regional population.

There are 4 levels of generation to be considered:

1. Large-scale grid connected generation. >100MW
2. Medium scale embedded generation usually interconnected to the transmission system via local line company sub-transmission networks. 10 – 100MW
3. Small scale distributed generation connected to distribution networks and/or embedded into large consumer installations. 0.5 – 10MW
4. Micro scale generation embedded behind consumer connections at low voltage with minimal export back into the local distribution network. 1 – 500kW.

Grid Connected Generation

Hydro generation at Tuapeka, Queensbury, and Lugget. These traditional projects are now proving difficult to achieve from a Resource Management Act perspective i.e. they don’t represent good practice in terms of resource management. They service loads that are too remote for good efficiency, they have high environment impacts, they are expensive and take a long time to develop and utilise capacity, and they increase sensitivity to dry years (due to lack of storage and diversity to existing generation).

NZ hydro development has tended to be “run-of-the-river” orientated rather than including the major storage component that is more typical overseas. Our rivers tend to be large volume, relatively reliable, and their generation is applied to base load. What storage there is, is there for managing operational variation between day and night demand variance. Hydro has the ability to turn on and off quickly and is more suited to load management applications than traditional thermal generation that targets base load.

Water storage is a possibility that has not had a great level of consideration in NZ because of its cost. However, it is a standard method of firming generation, and managing dry year reliability. Given that expenditure is required to address the dry year security issue, storage is likely to be a competitive option because the generation asset already exists. Storage can deliver other possibilities such as improving the reliability of irrigation and the possibility of developing pump storage schemes for peaking capability.

Otago with its mountainous valleys and capture of the snow melt has possibilities for large scale storage. However the existing commercial operators are unlikely to pursue such opportunities on their own initiative for the following reasons:

- The market pricing mechanism for electricity does not reward reserve capacity of this type.
- Generators who have enjoyed servicing base load will resist migrating to the more risky peak supply end of the market.

One issue with generation in the Otago region is that it is almost entirely hydro and therefore does not have much diversity. Adding more of the same generation type increases sensitivity to existing risk, i.e. dry years.

Wind is a significant opportunity for large-scale generation development, particularly in the Middlemarch/Lammerlaw/Lammermoore Range area. Wind is an unfirm source of generation but has a good synergy with hydro generation and storage. Therefore owners of large scale hydro have greatest opportunity for investing in large scale wind generation as they can manage the supply risks.

As the region has a large amount of hydro, which can be turned on and off quickly, the addition of wind generation would need to be very substantial before we would experience the power system stability problems seen overseas (thermal base load generation has a stability/economic issue with wind integration).

The addition of hydro storage is thus a partial solution to securing wind capacity.

Standby diesel generation is another option for securing hydro in dry years and for firming wind generation during daily peak periods. Such generation is viable for much longer periods than emergency peaking plant would target when managed in a portfolio of hydro and wind generation. The University of Otago has recently invested in two peaking systems that could be used as a backup supply. One system rated at 250 kW is presently running and a second system rated at 500kW will be operational within a month in the Medical School.

Meridian have investigated installing such generation in Southland in order to manage the security of the supply to the smelter and allow connection of wind generation.

Alternatively, this generation could be distributed around GXP's where there is a constraint during contingent events, a demonstrated need for security improvement (and not just at transmission level), and risk of isolation during extreme weather events.

Coal fired generation, whilst possible, has issues of being in the wrong location. Scale needs to be significant to make generation economic for transporting coal large distances. Direct application of coal to thermal end use is a more desirable local use of the resource. The issue is having a large enough user and meeting clean air requirements.

Embedded Generation

Medium scale embedded generation opportunities offers the potential to both optimise the match between local generation and local consumption. Which in turn would allow the region to decouple from the national price path for electricity by becoming more self-sufficient and improving the regions competitiveness as a location for economic development. In particular, use of the core grid can be reduced by using embedded generation to minimise the net demand presented to the grid.

Hydro, wind, biomass and coal have potentially viable and appropriately scaled opportunities throughout Otago. These opportunities compete with the economies of scale delivered by larger schemes by requiring less connection asset (transmission in particular) and supplying loads closer to the point generation. The key to this strategy is diversity of both location and mix of generation.

This situation presents an issue of establishing a generation portfolio and being able to manage it as a system. The region requires in the order of 400MW of firm generation to be completely self-sufficient. It already has 100MW of non-grid connected generation.

While management of air quality is an issue in some localities, the option of coal has been retained because it is an opportunity for South Otago where there is more flexibility in respect of acceptable sites. In terms of greenhouse gases, generation at a regional scale in new, efficient plant (and allowing for combined heat and power) will be more favourable than reliance on supply from Huntly as a result of old low efficiency technology and losses in transmission.

Distributed Generation

Small scale distributed generation matched to the load profile of every GXP is an ideal step towards modernisation of the power supply There are many opportunities to choose from. This form of generation niches itself into line company distribution networks where investment efficiency is maximised if they can avoid the need for line investment for their own connection, or allow capacity (and security) upgrades of the network to be deferred. For example, the University of Otago distributed generation entry to the grid is controlled by congestion signals from the lines company.

The main opportunities in Otago for distributed generation are hydro and wind. These can be viable at smaller scale where larger installations struggle because of their ability to match to network capacity.

Hydro supplied from irrigation infrastructure fits into this scale and there are significant opportunities on new irrigation schemes that have not been developed. The integration of wind, water storage and the options for pumping has not yet been explored in any detail.

Wood biomass (and waste) becomes an opportunity at this scale and can be integrated with a host industrial site such as a timber mill. These options can often prove more effective if the wood is used directly as an energy source without the step of generating electricity. Fuel quality can be managed by blending with coal or using supplemental firing with waste fuel oil.

Other forms of biomass opportunity exist for freezing works, municipal waste, sewage processing, etc.

The region's gas distribution infrastructures (pipe and bottle) present an opportunity for supporting electricity networks during peak periods i.e. the existing excess capacity in the gas infrastructure can overcome constraints in the electricity networks as occurs in the Christchurch Orion network. The region, however, does not have major issues with transmission constraints as faced by the Upper South Island.

Gas engines (and diesel to a lesser amount) are able to competitively supply peak weekday loads in order of 8 hours duration provided they are hosted at a site that can utilise the waste heat they produce. Hospitals, universities, and swimming pools with their large heating loads are ideal for this. Auckland hospital is an example. The gas engines also secure their electricity supply. These opportunities are ideally matched with landfill gas and coal seam gas utilisation.

All distribution networks have an opportunity to achieve viable transmission charge avoidance for approximately the top 5% of their load peak duration. Using gas or diesel engines as described above allows targeting of a duration of approximately 20%. Further, when additionally used in firming roles with other generation, a 30% duration is not unrealistic.

The benefits of diversity work both ways. The gas supply infrastructure can justify greater investment in capacity and security when applied to larger demands.

Also of note is the competition one fuel provides to another. Electricity prices have increased significantly faster than gas despite gas supply constraints. The options for fuel switching during electricity peak demand and high spot price is a means of balancing supply-pricing risk with increased demand response diversity.

Micro Generation

Micro generation includes household scale combined heat and power units (CHP). These are becoming a significant element in the energy systems of Europe and the US. This trend hasn't eventuated in NZ to date because our electricity prices haven't been as high, the gap between gas and electricity costs is not as great, and no subsidies are available. However this position is changing and the regulatory push to move away from wood and coal for domestic heating, and increasing diesel cost, may change the relative economics.

Wood pellet burners are an option for CHP systems and scaleable to light commercial users. The technology is relatively new to the market in NZ in terms of being a well-known commercial product. More market penetration is needed to improve the cost proposition to domestic users. Guaranteeing the supply of fuel at a continuing competitive cost is a marketing issue. Otago has an opportunity to be a leader in this technology and as the supplier of fuel.

While energy solutions other than direct generation in households can provide alternatives to using electricity and increase diversity against which load can be managed. They can equally have negative impacts. These are:

- Storage hot water cylinders and space heaters of sufficient capacity to only require supply for 8 hours per day. There has been a significant drop off in the installation of these appliances since the energy/line company regulatory split. Generators are not providing adequate energy price differentials and line company pricing signals are not being passed through by retailers. The capture of controllable load is being degraded accordingly as appliances go through a renewal cycle.
- There has been a national trend towards gas appliances for thermal loads (cooking and heating) and in particular instant hot water heaters. These present a risk to energy security in that they don't store energy and often require electricity to run. The population will become more sensitive to even relatively short term power outages.
- Solar hot water heating can be viable in parts of Otago despite consumer perception. Government initiatives are failing in the area of encouraging uptake especially compared to the situation in Australia where the installed cost of solar systems are considerably cheaper and large subsidies are available. Heat pumps for heating hot water are relatively new to the region but studies at Otago University indicate that they can outperform direct solar collection. Standby losses due to low average ambient temperatures continue to be a significant loss of capacity in Otago. BRANZ has found standby losses of up to 40% in conventional electric hot water heating systems.
- Space heating heat pumps/air conditioners have been a major trend in recent years in NZ and the nation is now starting to experience increased consumption and in some cases summer peaking being driven by air-conditioning. This has been a major problem overseas and can be expected to become so in New Zealand. This has the greatest potential to be a problem in inland Otago areas and adds to irrigation and holiday homes load driving high peak demands at small GXP's.
- Dehumidifiers and other trends in living comfort are also contributing to load growth trends. Dehumidifiers are a particular problem in Otago, as with the rest of New Zealand, as they are particularly associated with unflued gas heaters. Houses using unflued gas heating often generate so much moisture from the burnt gas that dehumidification is needed.
- Log burners, particularly those able to be used for cooking and/or hot water, make a significant contribution to energy supply in Otago's domestic households. Of particular issue is that ownership of a log burner means that the household will have several months of fuel stored. This gives considerable security of space heating supply during times of electricity outage or isolation during extreme weather events.

Barriers to Generation Investment

It is likely that existing owners of large-scale generation will continue to invest in large-scale generation opportunities in line with their existing generation portfolio. Regional policies are unlikely to have a major impact on these investments. National policy will be more important in establishing investment priorities and timing. A key issue in a small New Zealand market are the risks associated with bringing large-scale generation into the generation mix.

In this respect, wind is a preferred option.

- Their investment risk can be spread over a large portfolio of existing generation. Average costing allows hurdles to lowered. Any price increase that new investment can drive increases the profitability of their existing investments.
- They have the fund raising capability.
- Their customer base underwrites risk, hedges price (they don't need to sell to competing interests), and carries the project until load growth matches the increment in capacity.

Of note is that Trustpower was recently on public record stating that it is unlikely to invest in South Island generation until their issue with charges for using the HVDC Link are resolved. It is however assumed that if they get their resource consent for their proposed wind farm in Otago they will use it.

Otago Line companies have all indicated that in the right circumstances they would pursue distributed generation opportunities. These circumstances are:

- Re-establishing the generation operating capability they carried in-house before the reforms.
- Removal of regulations that constrain what generation they can invest in, its capacity and who they sell to.
- Ability to establish a balanced but diverse portfolio generation. Firm generation is needed to integrate with line assets and deliver optimal supply. Inability to hedge is a related problem.
- Ability to make higher profits than they can via alternative investment to line assets.

Again, this is a matter of national policy. Line companies are therefore likely to remain limited fringe players in small-scale generation in the short- to medium-term.

The situation in NZ is quite unlike that in parts of Europe where small landowners and individuals have participated to a large extent in the wind power boom, particularly in countries such as Denmark and Germany. This difference has meant quite different perceptions from the local communities between Europe and New Zealand in terms of preferences for wind power. There could be a niche opportunity for a regional council such as ORC to provide a cooperative framework to enable small holders to participate in the wind farm industry. This opportunity will further open as the economics of wind generated electricity improve.

Beyond the strict commercial issues, for consumers to become investors in generation they need:

- Access to expertise in generation and industry knowledge. This is often difficult for industry to assess.
- Generation opportunities preferably within their installation matched to their existing connection capacity.
- Access to expertise to design, build and operate plant.
- Having an existing means of hedging their output without relying on their competitors or without a well matched consumer base.

These are not trivial issues and thus line companies remain the most likely developers of local generation opportunities. Regulation constrains the type of generation that a line company is likely to target. It wants generation that contributes solutions to line issues such as capacity voltage, support, and security. These tend to be firm generation options and preclude stand-alone wind for example.

Without an existing generation base or the ability to compete in the energy sector the energy related benefits of generation offer limited value to line companies.

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7 VULNERABILITY & OPPORTUNITY ASSESSMENT

The supply of energy in sufficient quantities to meet demand and at an affordable price is highly valued by today's society. In this study we have begun the process of assessing the vulnerabilities (and opportunities) to the Otago region for meeting its future energy needs. The vulnerabilities described in the earlier sections of this report suggest that there are a range of risk factors likely to influence future supply pathways. These factors range from institutional capabilities through to demographic trends and specific location and network issues.

Because of the limited nature of this study, it has not been possible to assess these issues in depth, nor have we sought to provide a formal risk assessment or quantify the likely consequence of any loss event. This was not the purpose of the study. Instead, we have sought to provide an objective assessment of the key vulnerabilities of the important supply chains within the context of the total regional energy system. This we describe below, firstly for the fuel supply chains and, secondly, the electricity network. The final concluding section of the report is directed towards characterising the vulnerabilities exposed as a basis for future action.

7.1 FUEL SUPPLIERS

WOOD

In the short term the following trends can be expected:

- The market is a mix of informal network sources and formal suppliers. In Otago 62% of households use wood, and 32% continued to use coal for space heating.
- Reduced plantings in regional forestry estate should have no impact on the supply of firewood which is plentiful. Predictions of the country's forest estate shrinking and restrictions to new planting are unlikely to materially effect supply in the near term.
- A new direct competitor to split firewood is wood pellets with the associated move to a more formal market and a greater reliance on a single distribution chain.
- Air quality legislation will drive a higher standard in wood drying and, again engender, a shift to the formal market. This situation will also have an immediate effect on fuel choices for new home builders/ renovators and long term effects on current older style wood burners.

There will be a shift towards the formal wood supply market in urban areas, and in all likelihood an increase in firewood prices. In the long-term, it is anticipated that wood in some form will remain an important component of the regional domestic thermal fuels.

It is a real possibility that changes in regulations and fuel quality could lead to higher levels of fuel poverty. Homes with solid fuel burning appliance have been shown to be considerably warmer on average than those using other appliances. Swapping to other fuel sources would increase loading on those supply chains that may not have been planned for (or under estimated) as well as potentially reducing domestic resilience to disruption to supply or regional disruption events.

COAL

There are a number of factors affecting future coal supplies:

- Locally available sources will see the maintenance of current supply.
- Domestic use of coal is likely to decrease with the air quality regulations and Solid Energy's response in removing its product from the market.
- There is significant potential for increased usage of coal from local resources. This would require the application of international best practices and be most likely aimed at industrial and export markets. The local supply upside could see significant infrastructure investment within the region, with commensurate shifts in energy use patterns.
- The air quality regulations will lead to increasing requirements for commercial and

industrial users to incorporate mitigation measures in order to get consents. This may lead to fuel swapping.

- There is a long-established formal market in place with low relative prices due to the lower transport costs. The price is likely to remain stable and be partially insulated from international prices.

PETROLEUM

Petroleum is supplied from sources external to the region and is dependent on a specialised supply chain. Future factors include:

- The region, in common with the remainder of New Zealand, is exposed to world oil prices and the vulnerabilities associated with temporary disruption of supply, resulting in a short-term surge in the crude oil price, and long-term global market trends, in a tightening supply environment.
- In the last 2 years, automotive fuel has increased almost double. We are currently, in real terms, 20c away from the peak prices seen in the 1976-1985 oil crisis decade.
- There is recognition of the possibility of peak oil occurring within a decade. Of course we will never know when this point is reached as the world's hydrocarbon endowment, by definition, can never be measured. We can, however, anticipate an emerging supply/demand gap over the next decade. This gap will suggest that long-term changes in hydrocarbon intensity may be a useful pre-emptive move depending on the balance between long-term risk and affordability for the region.
- Regional supply is vulnerable to the disruption of tanker deliveries. Although it is common practice to source from Dunedin, Bluff or Timaru for delivery in Otago, the same tanker on the same supply run generally supplies to these storage sites. There is an alternative source direct from Australia, but depending on the timing of the disruption, there may be a reasonable time period before resupply could occur.
- New Zealand is known to have lower storage back up than is required by the IEA. Whilst the country is trying to address this issue nationally, preference is likely to be given to the major centres before addressing the needs of rural communities.
- There are multiple supply chains within the region utilising road tankers. As a consequence, relatively small storage levels are disbursed through out the region.
- The Farming and Tourism sectors are very reliant on transportation fuels and are vulnerable to supply failures, pricing changes and price shocks; including those incurred by changes in the value of the NZ dollar.

In the medium- to long-term, there is the opportunity for Otago to look at transport fuel options from local resources. Examples could be lignite, petroleum or gas from the Great South and Canterbury Basins; but the choices will ultimately be driven by affordability of the fuel and environmental considerations.

We note in addition that commercial agents claim they cannot justify holding large oil stocks for the long term as a contingency against supply disruption. The private storage costs are too high and the likelihood of disruptions too small. In these circumstances the direct benefits to the private agent of investing in additional storage are too low. Unless the government provides incentives for added storage, private inventories are principally 'working stocks' and are not designed to hold reserves for externally-induced supply disruptions. They are held to ensure reliable plant operations and process flows in the face of routine logistical delays, normal demand fluctuations and modest short term price variations.

The MED has undertaken a detailed analysis of the external and internal events most likely to disrupt New Zealand's oil security, in terms of magnitude, duration and probability. They concluded that by far the biggest risk would be a global oil crisis. While there are ongoing domestic supply risks, particularly outages at the refinery, the Wiri oil terminal and the refinery to Auckland pipeline, the probability, duration and magnitude of these are an order of magnitude lower than a possible global crisis.

LPG

This fuel should be viewed as a critical supply chain. LPG is supplied from sources external to Otago and is dependent on specialised equipment and a specialised supply chain. Key vulnerabilities identified include:

- Exposure to world gas prices. Price is set on world prices so very susceptible to price shock. There are no quick fuel alternatives to LPG gas.
- Regional supply is vulnerable to the disruption of tanker deliveries. The Liquigas storage facility has only the equivalent capacity of a single tanker, so a just in time supply is method is used with generally 1-2 days capacity left when each shipment arrives in port. Todd Energy use rail with deliveries every 2-3 days and topping up supply from the Liquigas terminal.
- In total, Otago has only about a weeks buffer for late delivery before wide scale gas shortages would occur (estimate that between 10-15% of users need replenishing at any one day, depending on size of tanks used). The reticulated gas in Dunedin is more resilient in that it can source gas from the Liquigas terminal if its rail shipments are disrupted.
- The main storage for South of Oamaru is the Liquigas terminal with storage levels disbursed throughout the region. Increasing regional demand and population growth will place additional pressure on storage capacities.
- There are multiple supply chains with in the region utilising road tankers.
- Public opposition has a serious effect on the ability to increase storage or put in new storage due to the perceived risks of LPG storage with regards the high consequences even if a low probability event.

TRANSPORTATION

A potential vulnerability for petroleum and LPG supply in Otago is the road networks used by the distribution fleets. A basic assessment by historical incidence of road closure (see below) showed that there has been, in the past, no sustained closure that would not allow another access route or last long enough to cause major disruption in the urban centres.

7.2 ELECTRICITY SUPPLY

Electrical Supply is more susceptible to weather events than other fuels. This is especially so for Otago with its large proportion of rural systems with low volume loads that does not make higher security designs cost effective. On the basis of the analysis undertaken in this report the following key vulnerabilities have been identified:

- The topographic nature of Otago has lead to limited interconnectivity of distribution systems and limited redundancy in network designs.
- Security standards vary from line company to line company within the region. Industry level security standards are not generally attained, but higher levels of reliability are enforced.
- The changing demographic make up of Otago and the rapid growth in some areas may cause projected growth to be underestimated and insufficient capacity to meet demand.
- At a system level Otago does not necessarily have n-1 security to most urban areas in Otago. The low Otago VoLL reflects the lack of high density cities and leaves exposed rural communities to longer duration outages.
- Changing demographics and consumer preferences will lead to a greater shift to electric thermal load.
- Power quality in the rural areas will start to become more of an issue especially with

SH1 Oamaru - Dunedin	1 12 hr period
SH1 Dunedin - Invercargill	1 6 hr period
SH6 Haast - Wanaka	2 x 24 hrs, and 2 x 12 hrs (nighttime)
SH8 Omarama - Tarras (Lindis Pass)	7 nights for 12 hr period, 2 days (24 hr period)
SH8 Raes Junction - Alexandra	Flooding hazard in 3 year intervals
SH85 Palmertson - Alexandra	3 nights 12 hr periods, 1 day (daytime) 4 hr period
SH94 Milford Road (Te Anau - Milford)	15 days 24 hr periods.
SH1 Oamaru – Dunedin	4hrs twice a year sow on Northern M/way Flooding Hazard in 5 year intervals

Road Closure Incidence (anecdotal from Transit)

increasing sophistication of rural businesses and the demands of the visitor industry.

- There is a lack of understanding of the interdependencies of modern society with electric power supply and other supply chains.

Further risks to the electricity supply chain includes technology changes, significant load pattern changes either by customer group or throughout the network, regulatory changes and finally economic changes.

Limited distributed generation has been installed (or connected) within the region to date and with only one incumbent, Pioneer Energy, active in the field. Depending on the location and capacity of any proposed new generation, significant upgrade to local networks may be required.

Despite evidence that suggests otherwise, review of the lines companies' asset management plans shows that all current projections are based on no significant changes with respect to the local economy or load pattern changes of a general nature. This seems a false premise for future planning. This review has clearly identified irrigation, more intensive agriculture, and now urban development in Central Otago as driving a fundamental shift in energy end-use patterns.

Industry Security Standards

The scope of the electricity network review in the Otago Region did not extend to a full analysis of compliance with the “n-1” criterion. Review of the three network company Asset Management Plans offers a dramatic confirmation that ‘true’ security is rare within the region.

The outcome targeted by networks is the least customer-minutes of unserved energy (i.e. small and localised interruptions OK) not the least number of interruptions which a more pure definition of reliability might imply. Security is slightly different again in that it is tolerance to faults without interruption. The networks are characterised by low security, good reliability, and high availability.

We would suggest that given there is good performance relative to other parts of the country there is very little management focus on the issue on security enhancement. This is one of downsides to regulatory performance management: you get regulatory compliance whether or not its an improvement in every circumstance.

Reported Performance Criteria

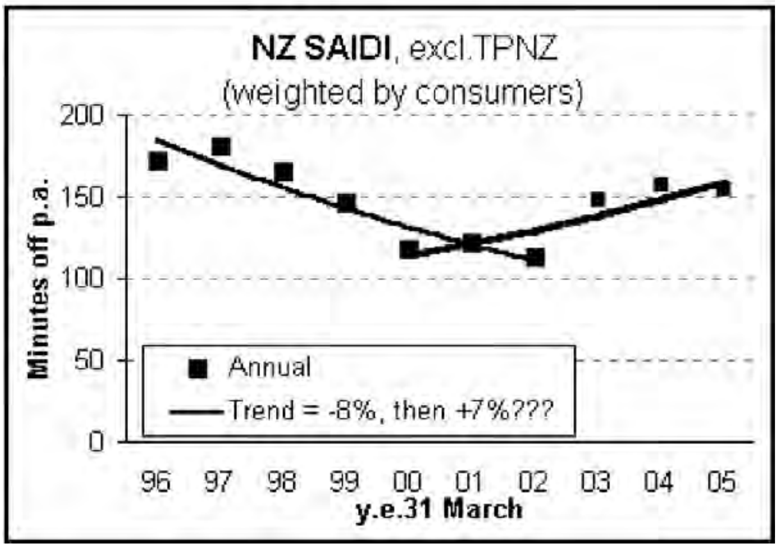
As noted previously, network companies are obliged to publish the agreed performance criteria and measures of supply to their consumers under the Electricity (Information Disclosure) Regulations in their annual Asset Management Plans or Network Performance Reports. These criteria are summarised as the SAIDI, SAIFI and CAIDI figures for the network and trends are easily established.

The SAIDI measure, which is commonly used, measures outage not reliability, i.e. it includes planned outages as well as faults and therefore is just as likely to be influenced by operating practices than by asset issues. The measure becomes very sensitive to single events when high levels of performance are being achieved (not linear). A network with a 60 minute SAIDI experiencing a system-wide 2 hour event will see a massive degradation of its performance. Whereas a network with 180 minute SAIDI would see an improvement in its average performance if subject to the same duration event. For this reason SAIDI is only used to indicate trends within a network over averaged several years. Saidi can very volatile from year to year even 5 year rolling average may be a fair indicator for sensitive networks. All network have a different base line Saidi for performance monitoring. The actual value from the regulators view is irrelevant they just look for improvement in the underlying long-term trend.

Thus when reviewing such reported measures, care must be taken in the interpretation; for example, the figure below describes the national SAIDA performance from 1996. Although the recent trend is for increasing national SAIDI results, it probably reflects the need to upgrade with associated planned outages and it also probably follows economic growth and asset age cycles.

SNOW LOADINGS

Otago line companies include contingencies for



National SAIDI Time Series

snow load in their design standards. It is reasonable to expect that main lines and sub-transmission systems to be built to standards where snow will not cause damage. However at the fringes of a network, where supply is less economic, design standards will be deliberately lower. In this case it is more cost effective to repair damage rather than prevent it through over-design. (This is a contentious issue for rural consumers.)

However the recent snow in Canterbury has highlighted a design issue. The designed standard shared by lower South Island line companies applies snow-loading contingency on the basis of altitude. The assumption is that the higher the altitude the more likely and heavy the snow will be. With snow right down to sea level this assumption has proven to be incorrect. A high proportion of damage was caused in areas below 500m where lighter conductor loads were permitted by the standard. Line companies will need to reassess their vulnerability in this regard. The type of wet snow conditions experienced recently was also not considered in the design guides.

Significant commercial loads tend not to be located in these areas and if they do, securing their individual installations is more cost effective with a localised solution such as a standby generator. Ski fields and tourism facilities are most at risk. Their special requirements can be addressed with individual tailored non-lines solutions which they should have some expectation of cost responsibility for.

Rural townships can be secured with line company owned generators. In the event of a high voltage outage the local low voltage reticulation can be used to service the township on an islanded basis. A standby generator can deliver higher security than a second transformer at a zone substation for example.

Lighter design standards were often applied when rural electrification was being progressed. Legacy assets from this period and particularly those, which has been converted for higher service applications, are vulnerable.

Flat line structures (conductors arranged on a horizontal plane) and dedicated poles without under-built circuits provide superior robustness in terms of conductor clashing as snow falls off conductors. None of the Otago line companies retain this design practice today. Establishing new line routes and associated costs such as easements and resource consents have become prohibitive to this practice.

During a heavy snow event the main operational issues are:

- Civil defence does not deploy early enough as the scale of event can take more than a day to identify. When line companies are left on their own there may be hesitation in committing expensive resources such as helicopters that they are expected to pay for but cannot cover cost with insurance.
- Inability to access sites for fault isolation, identification of repair required and for the repair itself. It can take up to three days identifying the scale of the problem. Early access to helicopters for patrolling, etc. is required. Even a pole 6m from the roads edge can be too difficult to reach in snow. Closure of the main road passes isolating areas is a very common event in Otago.
- Helicopters and other quick response and standby plant require fuel dumps.
- A lot of minor damage is caused which does not initially result in a fault. As snow melts or during subsequent poor weather the incidence of faults can be expected to increase.
- Communications systems battery banks go flat preventing consumers reporting faults and work crew coordination (this becomes a management limitation with respect to the number of field staff able to be deployed, etc.). Some rural telephone exchanges have very short battery back up (<12 hours i.e. overnight only). This is inadequate for accessing emergency services. Line company radio repeater sites need back up generation. Mobile phone networks need to ensure adequate backup supply as part of their licensing.
- Staff safety becomes a major issue. Staff have to do more work manually (like carry in ladders), they get fatigued quickly, obstacles are not visible, and they are vulnerable to exposure. Working at night is not safe and crews need to be brought in early for a head count.
- Equipment usually needs to be operated

manually. Automation and fault indicating equipment will speed response times.

- Familiarity with the local network is an issue for “out of town” crews. Non-specialist staffs need to be employed to procure/deliver material, dig holes, etc. Resourcing is rarely an issue as most companies can find as much local resource as they can manage in the field, except in the case of widespread weather related outages, like the recent snow storms.
- Line companies will respond on the basis of restoring power to the most people they can, as quickly as possible. This can result in disconnection of individual connections to allow the main line to be restored. Furthermore, they will restore their networks (which end at the consumers point of connection) before attended to faults on consumer owned assets. They can tie up contracting resources for weeks while undertaking permanent repair. This can leave individual consumers stranded even though a minimum of network supply has been restored.
- Farming operations with a dependency on electricity, such as dairy sheds, need to have their own contingency provisions. This becomes an animal welfare issue and options are limited during the event. This is an issue in local areas where dairy conversion is prevalent. Networks often have not been designed for the service levels required for milking and its refrigeration.

ESSENTIAL SERVICES

Most essential services and civil defence organisations have sufficient contingencies to operate adequately through a major period of outage. The weaknesses are:

- Water schemes particularly those in rural areas including stock water. Provision for connection of generators (or direct non-electric pumping) should be a consideration. This includes treatment plants, reservoirs, etc. Dehydration is an issue in cold conditions that is often overlooked. Importantly, Dunedin water supply and treatment stations have no backup electricity supply and could not provide treated water for more than a few days after supply failure.
- Sewage systems tend to have very limited storage capacity and no back up electricity supplies at local pumping station, which would cause overflow difficulties should supply fail before they start to overflow. There is often less storage than the average line company fault response time. Rain creates extra stress on these systems.
- Schools tend to be overlooked. These can be very large users of electricity and can have boarders to care for. School facilities can offer emergency shelter, cooking and coal fired heating for communities. Their incorporation into emergency plans should be considered. They would be an ideal site for backup generation.
- Supermarkets and coldstores are also overlooked. These carry the community’s emergency food store (approximately enough for 3-4 days). Plans for keeping them operational and freezers operational should be checked.
- Petrol stations also hold essential supplies during an emergency and are unlikely to have contingency power supplies. Without power they cannot pump or operate. Rural petrol stations are becoming fewer so strategic stocks are no longer local resources.
- All emergency services and facilities with backup generators need to consider storing a minimum of 100 hours fuel on site. Bulk supply may not be available and delivery impeded. Contingency plans appear to assume that no one else will be competing for fuel supply. The trucks and vehicles used for emergency response also need adequate fuel reserves. Winter diesel fuel stocks also need to be reviewed for adequacy in an emergency or prolonged weather situation.
- When widespread failure of street lighting occurs an increase in crime is a common consequence.
- Financial services are also vulnerable to electricity supply failure as in todays ‘plastic money’ society, individual holding of cash is generally low. There are currently no contingency plans for providing critical cash dispensing facilities; these would require secure electricity and telecommunication links.
- The ability of the transmission and generation systems to black start and run islanded from the rest of the South Island should be investigated. This requires

coordination of load connection with line companies. It is assumed that no plans have been identified for this contingency.

INTERDEPENDENCIES ON ELECTRICITY

In addition to the above, it is also worth reflecting on the interdependencies that govern infrastructure resilience and the individual's capacity to cope with a major disruptive event. Examples brought to the attention of the study team during the course of their work include (in no particular order):

- Pellet fires require electricity to operate, in the event of a disruption to electricity supply, both primary heat sources in a house could be lost.
- Gas hot water systems require electric power for control operations.
- Conversions to other fuels has in some cases increased vulnerability from an electric supply disruption. A move away from domestic coal and wood would also removed contingent fuel reserves from domestic residents.
- Communication systems batteries are reliant on 'mains' supply for recharging. The lack of communications directly affects banking and other financial services.
- Water supplies, fuel systems, control systems and signalling, transportation and a myriad of other applications all rely on electricity.

Addressing the issues is a lifelines engineering issue, in which New Zealand has significant capacity. Unfortunately, experience demonstrates that our critical infrastructure is owned by no single group or organisation in society and coherent action is often difficult to achieve. Collaboration and co-operation is essential if information is to be shared across sectors in order that an optimal solution can be arrived at. These issues emphasise the need for new approaches to energy systems planning.

7.3 FUTURE STRATEGIES

Moving forward will require the Otago Regional Council to better articulate the critical energy issues for the region and decide on the tradeoffs needed to reach a balanced position on energy supply that takes account of security, risk, economic opportunity and consumer preferences. This report should articulate a road map for determining future energy options for Otago and a framework for regulatory decision-making.

What we know from this study is that the vulnerability chain extends from primary fuels supply, through the entire supply chain to the individual consumer. The critical interactions and interdependencies that govern the performance of this complex system, in turn, present their own vulnerabilities and risks.

We need to define the problem broadly and provide improved choices and robust solutions for improving resilience and investment in the underpinning infrastructure to the betterment of all in the region. This entails informed decision-making, local solutions and dialogue, that leads to shared responsibility for multiple and, sometimes conflicting, objectives.

Areas of priority identified by the study team have been summerised in the table that follows.

Finally, we comment that, as a region, Otago is inherently energy rich. This report has identified a number of supply side options available to the region that will enable better management of the risks and vulnerabilities to the regional energy system. The fact that currently there is only one local company with a reasonable generation portfolio in the region should be a matter of public concern.

At a national level Otago supplies considerable energy into the national grid for transmission to the Upper South Island and North Island demand centres. Investment in wind and hydro as announced will do little more than increase those deliveries, and will do little to contribute to regional energy security.

Water storage is a possibility that has not had a great deal of consideration. For a region increasingly reliant on irrigation and intensive agriculture it would seem logical to explore multi-use opportunities. Storage can deliver opportunities for the region to improve reliability of irrigation as well as peaking capability to meet capacity constraints at the national level.

The major strategic energy reserves embedded

Supply Chain Component	**Hazard**	**Vulnerability**	**Consequence* (+ effects)**
Electricity Supply	Weather Events - Snow - Flooding	Low security standards leave rural connections exposed to longer duration outages	Moderate
	Man-made Hazards - fire - accidental loss	Low security levels and limited interconnection at subtransmission level creates high risk of disruption	Low
	Capacity constraints - increased demand from irrigation, intensive farming - demographic shifts to Central Otago and coastal settlements - changing load patterns, eg uptake of heat pumps	Lack of coordination at the regional level. Incumbent line companies using historical trends Summer peaks dominating and increasing load factors	Severe
	Regulatory Frameworks - investment criteria - planning policy limits	Individual users unable to support cost of upgrade investments, thereby limiting economic opportunity in defining essential works	Moderate
	Distributed Generation Connection - incremental upgrades limit connection - GIT does not support new transmission upgrades in the region	Significant upgrade to subtransmission required for DG connection deters investment The 110kV transmission system stretched, limited capacity for significant new loads limiting economic development opportunities	Severe
LPG Supply	Weather Events - Snow - Flooding	Extended distribution and supply reliant on specialist supply chain. Low levels of home storage and dependency on electricity will see supplies rapidly depleted	Low
	Man-made Hazards - accident - industrial dispute	Regional supply vulnerable to disruption of tanker deliveries and road transport. Late delivery will lead to wide-scale gas shortages	Moderate
Other Thermal Fuels	Environmental - Fuel switching from coal (and wood) to LPG - Conversion of new households to electricity - Public opposition to new LPG storage	Fuel switching and the uptake of new clean burning appliances, instant hot water etc., increases dependency on secure electricity supply	Moderate
Consumer Demand	Fuel Poverty - household energy costs >10% - transportation cost	- air quality regulations forcing formal fuels market, limiting access to “free” fuel - potential supply shortfalls and the requirement for upgrade at both transmission and distribution levels is seeing increasing electricity costs, and a greater proportion of households spending more than 10% of their income on home heating - A doubling of transport fuel prices, and the cost of petroleum fuels for direct use is making SI industry (inc. tourism) less competitive with NI and Australian counterparts	Low
Essential Services	- increasing electricity dependence	Increasing use of remote sensing, distributed control and ICT in our essential services results in increased dependency on a secure electrical supply	Low

* Consequence has not been quantified; instead an arbitrary scale from low through to severe has been attributed to industrial vulnerability. Further more detailed work and quantitative analysis is required before a formal risk management framework is possible.

Identified energy supply vulnerabilities in Otago in the Otago/Southland lignite resources offer the potential for further major energy industries in the region. The flow-on effect of these developments, should they proceed, will be of major importance to the region. Properly addressed and sensibly progressed, these resources have the potential to deliver considerable economic benefit and energy security for the region.

Beyond these opportunities, small-scale distributed generation matched to load profile of individual GXPs within the region is an ideal step towards modernisation of the electricity supply system. There are many applications to choose from; small-scale hydro, through to biomass, coal-seam gas and diesel engines. The benefits of diversity enables economic development which also contributes to resolving the capacity and security issues being driven by demand growth and requirements for improved power quality.

All the above options need further, more detailed investigation and assessment so as to provide a road map for determining future energy options for the region. As stated at the beginning of the report, 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. Without specific action there is a risk of insufficient investment in peak generation capacity or spare capacity to allow connection of new major users without the required investment deterring such economic growth.

In addition, including distributed energy and the potential for remote area power generation is an essential component in determining the desired set of outcomes for local energy infrastructure investment. For example, there are some exciting new developments in the photovoltaic industry, which together with local wind farm deployment and other emerging storage technologies could lead to significant microgeneration opportunities and novel network design for the future. These factors need to be taken into account in examining future policy options.

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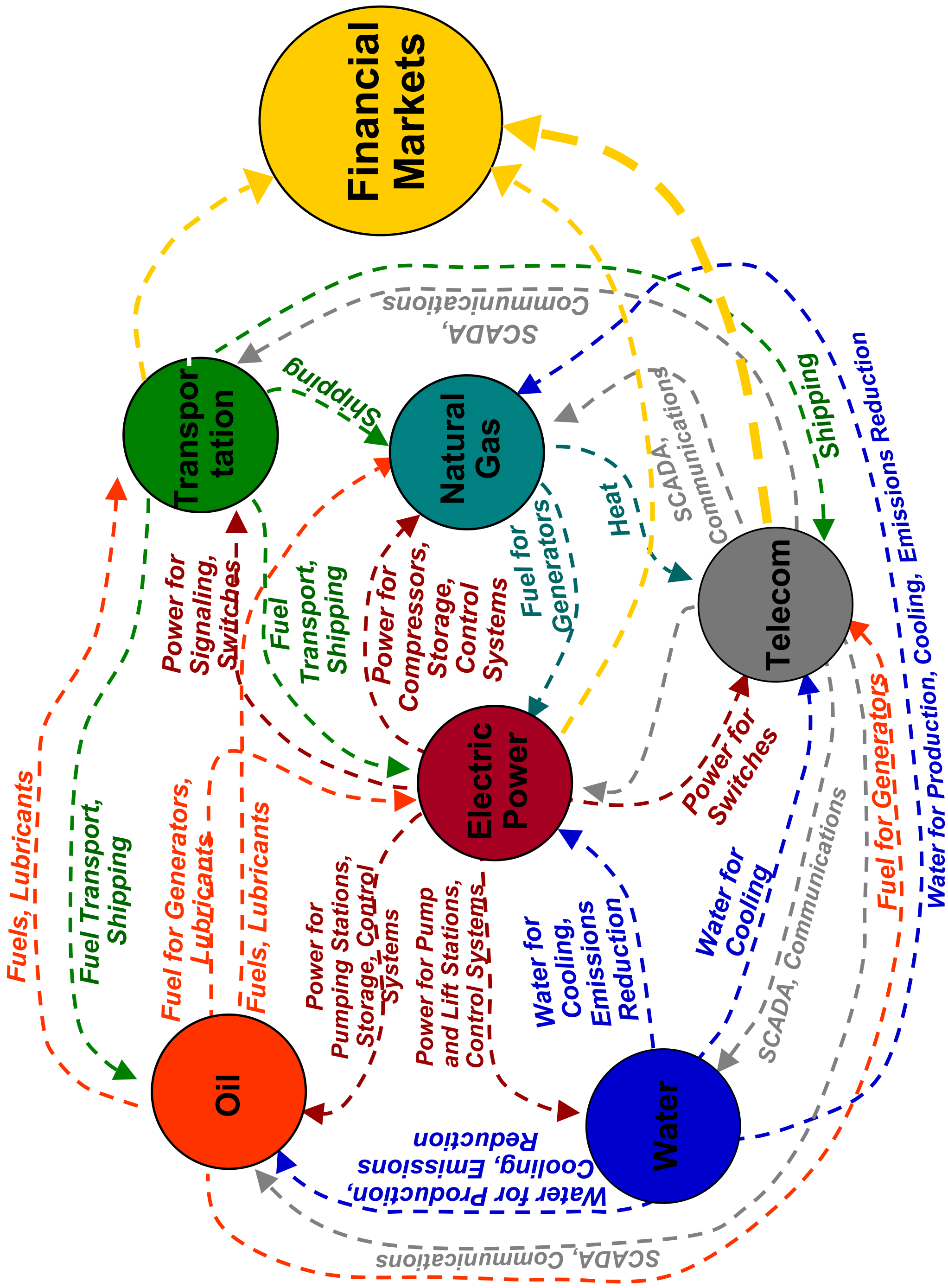
APPENDICES

APPENDIX 1: Interdependency between energy forms



O'Rourke from Peerenboom, Fisher, and Whitfield, 2001

APPENDIX 2: Otago heat plant sized over 1MW

Company	Plant	Boiler make	Type	Installed	Capacity MW_T	Output	Pressure (bar)	Fuel	Consumption
Fonterra	Stirling	John Thompson	Watertube	2003	35	Sat. Steam	42	Lignite	
		Foster Wheeler	Watertube	2001	17.5	Sat. Steam	10	Lignite	1250 T/M
University of Otago	Chem. Dept.		Firetube	2001	2.3	Hot water		Oil	
			Firetube	2001	2.3	Hot water		Oil	
Abco Meats	Otago	Anderson			0.75	Hot water	4.4	Coal	
Energy for Industry	Dunedin Hospital	Daniel Adamson	Waterwall	1958	6.83	Sat. Steam	10.3	Coal	
		Daniel Adamson	Waterwall	1958	6.83	Sat. Steam	10.3	Coal	
		John Thomson	Waterwall	1967	7.39	Sat. Steam	10.3	Coal	
		John Thomson	Waterwall	1980	7.65	Sat. Steam	10.3	Coal	
Sealord Group	Birch St, Dunedin	Anderson	Firetube	1973	1	Sat. Steam	10	Oil/Diesel	12.5L/h
Speights	Dunedin	Scott		1920	1			Coal	
		Scott		1920	1.4			Coal	
		Scott		1984	1.4			Coal	
		Scott		1984	1.4			Coal	
Ravensdown	Ravensbourne	Babcock & Wilcox	Firetube	1967	9.2	Superheated Steam	21.4		
Craigpine Timber	Winton	Morrow eng.	Watertube	2001	7	High pressure hot water		Shavings & sawdust	Max 6330 MJ/h
Findlater Sawmilling	Winton	Babcobk & Wilcox	Triple pass economic wet back	1986	4	steam	105	Wood waste	
		John Thompson	Triple pass economic wet back	1968	6	Hot water	10.5	Wood waste	
Blue Mountain Lumber	Tapanui	Easteel	Waterwall	2000	10	Superheated steam	28.5	Woodwaste	
Blue Mountain Lumber	Whitianga Sawmill			2004					
City Forests	Milton	Vekos		2004	4.5	Hot water		Coal	
Millstream lumber	Milton	Kablitz	Waterwall	1995	5	Hot water	12	Woodwaste	
Stuart Timber Company	Tapanui		Direct fired						
Taeri	Taeri			2006	4.5			Dry shavings & hog fuel	
Wenita Forest Products	Rosebank sawmill, Balclutha	Scotts	Firetube	1994	2	Hot water	10	Coal	500 kg/h max

APPENDIX 3: Energy use in Otago

Fuel (Aggregated List)	**Sector** (Aggregated List)	**Enduse** (Aggregated List)	**Technology** (Aggregated List)	**MWh**
Biomass	Commerce	Heating	Heat Devices	1557.37
Biomass	Household	Heating	Heat Devices	22243.63
Biomass	Industry	Heating	Heat Devices	230723.02
Electricity	Agriculture	Electronics & Lighting	Electronics & Lights	1302.35
Electricity	Agriculture	Heating	Heat Devices	8744.61
Electricity	Agriculture	Stationary Motive Power	Motors	45708.07
Electricity	Commerce	Electronics & Lighting	Electronics & Lights	33194.69
Electricity	Commerce	Heating	Heat Devices	124759.65
Electricity	Commerce	Heating	Motors	89466.7
Electricity	Commerce	Stationary Motive Power	Motors	109674.24
Electricity	Household	Electronics & Lighting	Electronics & Lights	35533
Electricity	Household	Heating	Heat Devices	426020.25
Electricity	Household	Heating	Motors	5303.41
Electricity	Household	Stationary Motive Power	Motors	55672.71
Electricity	Industry	Electronics & Lighting	Electronics & Lights	4528.87
Electricity	Industry	Heating	Heat Devices	55695.62
Electricity	Industry	Heating	Motors	5130.72
Electricity	Industry	Stationary Motive Power	Motors	284814.33
Electricity	Transport & Storage	Electronics & Lighting	Electronics & Lights	3380.08
Electricity	Transport & Storage	Stationary Motive Power	Motors	4172.64
Fossil Fuel (Non-Transport)	Agriculture	Heating	Heat Devices	22267.48
Fossil Fuel (Non-Transport)	Agriculture	Stationary Motive Power	Motors	3584.13
Fossil Fuel (Non-Transport)	Agriculture	Transportation	Transport	28974.55
Fossil Fuel (Non-Transport)	Commerce	Heating	Heat Devices	126727.19
Fossil Fuel (Non-Transport)	Commerce	Transportation	Transport	24.68
Fossil Fuel (Non-Transport)	Household	Heating	Heat Devices	37179.78
Fossil Fuel (Non-Transport)	Industry	Heating	Heat Devices	289904.59
Fossil Fuel (Non-Transport)	Industry	Stationary Motive Power	Motors	2724.71
Fossil Fuel (Non-Transport)	Industry	Transportation	Transport	8718.56
Fossil Fuel (Transport)	Agriculture	Transportation	Transport	21063.8
Fossil Fuel (Transport)	Commerce	Transportation	Transport	16156.73
Fossil Fuel (Transport)	Household	Transportation	Transport	164176.25
Fossil Fuel (Transport)	Industry	Transportation	Transport	11797.67
Fossil Fuel (Transport)	Transport & Storage	Transportation	Transport	172126.43
Total				**2453052.52**

Source: Estimates from the EECA Energy End Use Database, link: http: //www.eeca.govt.nz/enduse/EEUDBMain.aspx
Disclaimer: Please note these results are estimates only and are derived from high level data.

APPENDIX 4: DG Guidelines

The following guidelines with regard to diversity and capacity of distributed generation are recommended for line companies:

- A typical GXP load profile can be considered as consisting of three elements that typically equate to one third of the peak demand each; anytime base load, week day base load, and week day peak load.
- Generation that targets base load application should therefore not exceed about a third of the GXP demand unless exporting to the grid is viable. Base load generation would ideally be a firm application spread over more than one site to spread the risk of non-availability. CHP should target the the gap between summer and winter base loads as heating is turned off during summer.
- Weekday base load is an ideal target for hydrogenation with some storage capability. The generation can be run at a higher peak output for say 10 hours per day and a reduced output storing water at other times. Multiple machines and/or sites address availability issues. A disadvantage of hydro is that there is no choice about where the generation can be located in the network and any scale will therefore require sub-transmission development. Storage is an important element in a generation portfolio as it allows the benefits of other less firm generation to be maximised.
- Peak management can be economically served by relatively expensive forms of generation because duration is short and savings are high. Typically the peak demand exists for two 2 hour periods a day i.e. one third of networks capacity is only needed for one sixth of a day for approximately 100 days per year.
- Optimised load control systems can be expected to manage approximately half this peak demand. Diesel generation could be expected to manage the 5% of demand economically and gas engines in applications where their waste heat can be recovered will cover another 10%. Hospitals, civic buildings, universities, and swimming pools are ideal host loads for this generation.
- None of this asset needs to be owned by the line company. They do however require synchronisation and automation via the load control systems. These features are often absent from standby sets installed by end users because there is an absence of benefit pass through by line companies.
- The Congestion Period Demand pricing signal offered by DEL addresses this partially with consequence of users like Port Otago and the Dunedin Airport responding with the installation of their own standby power capability.
- Wind energy is only viable for networks in small quantities i.e. one to three machines at each site. This is an issue of the firming capacity and avoiding line reinforcements. There are a large number of smaller sized second hand turbines now available as large scale generators increase machine size for greater efficiencies. These are ideal for line company application and their lower cost means that they can be viable for lower quality wind resources more likely to be closer to network infrastructure, etc.
- Wind farm capacity would ideally be balanced with equivalent capacities in peaking plant and hydro with storage. With a balanced portfolio of generation wind capacity of up a third of peak demand should be possible without it competing against base load generation or creating control instability.

APPENDIX 5: Regional heating cost comparison

CITIES/TOWNS/ REGIONS	Northland	Auckland central/ Manakau	Auckland north/west	Waikato	Taupo	Gisborne	Tauranga	Rotorua	Taranaki	Wanganui	Manawatu
PLUG IN HEATER											
Daily charge	37.5	66.6	112.5	72.6	95.6	85.8	68.4	95.6	82.6	82.6	106.3
Cost per kWh	17.4	13.0	14.2	14.6	13.9	20.6	12.9	13.9	15.9	15.9	15.5
NIGHT STORE											
Daily charge	37.5	66.6	37.5	59.7	130.0	85.8	74.4	130.0	82.6	82.6	78.8
Cost per kWh	8.6	13.0	8.9	10.1	8.1	20.6	13.7	8.8	8.6	8.6	7.5
HEAT PUMP											
Daily charge	37.5	66.6	112.5	72.6	95.6	85.8	68.4	95.6	82.6	82.6	106.3
Cost per kWh	5.8	4.3	4.7	4.9	4.6	6.9	4.3	4.6	5.3	5.3	5.2
GAS											
Daily charge	52.3	75.4	75.4	68.4	57.4	102.4	57.4	57.4	81.6	102.9	106.9
Cost per kWh	11.9	8.6	8.6	8.3	7.5	9.1	7.5	7.0	6.5	5.8	8.6
FIREWOOD (cost per kWh)											
Woodburner	6.4	9.5	9.5	7.0	5.5	4.2	7.3	4.9	4.8	4.5	6.3
Closed fire	10.1	14.9	14.9	11.0	8.6	6.6	11.5	7.7	7.6	7.0	10.0
Open fire	30.3	44.8	44.8	33.0	25.8	19.9	34.4	23.0	22.7	21.1	30.1
CITIES/TOWNS/ REGIONS	**Hawkes Bay**	**Waira-rapa**	**Wellington**	**Marlborough**	**Nelson**	**Christ-church**	**Westland**	**South Canterbury**	**Dunedin**	**Invercargill**	
PLUG IN HEATER											
Daily charge	116.1	80.0	92.9	142.0	148.2	63.2	122.7	133.9	76.5	120.3	
Cost per kWh	15.2	18.8	15.4	13.9	13.4	16.4	15.8	12.7	14.3	13.6	
NIGHT STORE											
Daily charge	136.6	78.8	101.6	142.0	154.5	63.9	122.7	133.9	82.3	120.3	
Cost per kWh	13.8	8.2	7.7	8.8	9.0	8.0	6.9	12.7	8.7	8.0	
HEAT PUMP											
Daily charge	116.1	80.0	92.9	142.0	126.5	63.2	122.7	133.9	76.5	120.3	
Cost per kWh	5.1	6.3	5.1	4.7	4.7	5.5	5.3	4.2	4.8	4.5	
GAS											
Daily charge	104.1	38.8	112.3	28.5	28.5	26.3	32.1	24.7	37.0	34.5	
Cost per kWh	9.5	14.8	8.6	14.5	15.3	14.5	15.7	14.1	14.3	28.1	
FIREWOOD (cost per kWh)											
Woodburner	5.6	7.5	10.0	5.5	5.6	7.3	2.8	6.5	7.2	6.1	
Closed fire	8.9	11.8	15.8	8.6	8.8	11.5	4.4	10.2	11.3	9.6	
Open fire	26.7	35.5	47.3	25.9	26.5	34.6	13.2	30.7	33.8	28.7	

For the table[1] above, the costs are all in New Zealand cents (2005 data) and the units are kWh of useable heat energy and includes efficiency factors for the appliances. Electricity prices assume an all electric house and gas prices assume gas hot water heating as well.

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[1] Consumers institute website www.consumer.org.nz

APPENDIX 6: Sub-transmission Networks and Demand Growth

Aurora Energy - Extract from the 2006 Asset Management Plan

Supply Interruption

A thorough discussion of the principles applying to the design for and monitoring of supply reliability in New Zealand appears in the 1993 *Reliability of Electricity Supply* report by the Centre for Advanced Engineering. Many distribution businesses have adopted the tabular form of security guideline. This is a useful rule-of-thumb approach to network design in pursuit of performance levels expected by users of the assets, but it is dependent on engineers' perceptions of consumers' needs (e.g. larger load groups and "urban" feeders are generally assigned higher standards without the basis of the choice being explicit). Such a deterministic approach was used in the past by Aurora for the Dunedin City area, but has been replaced by a demand-side-driven probabilistic approach. This approach is more sophisticated, and is both facilitated by technology available today and in Aurora's view will lead to better asset utilisation and thus lower costs while meeting consumer expectations.

Put a Value on Avoidance of Interruption

Operating and design choices affect network performance and they are available both throughout the network and externally (transmission, embedded generation and interruptible load options). To assist the pricing of non-network options Aurora has adopted a "lostload" approach to reliability planning, by assigning a dollar value to supply interruptions, presently in the table below.

These values are used in assessing the cost of interruptions that result from asset operating and investment choices. Aurora has made these value assumptions *until asset users can agree on a better basis*. In view of the apparent preference by consumers for cost reduction over quality improvement, Aurora expects that the above values will be reduced over time, automatically rationing both operating expenditure and capital investment and thus delivering lower costs.

Network Development

Capital expenditure on the Aurora Network is driven by the following factors:

- growth in demand by existing consumers;
- connection of new consumers;
- replacement of aging equipment to meet safety and reliability standards;
- community requirement to convert overhead distribution to underground.

Aurora expects strong growth in electrical demand, in excess of 3% per annum, to continue in the areas served by the Frankton and Cromwell GXPs. This is supported by Statistics New Zealand prediction that the present population in the Queenstown Lakes District Council area could more than double during the next 20 years.

Planning Criteria

Planning decisions within the electrical distribution industry have historically been deterministic and sometimes overly conservative. In the past the "n-1" criterion was applied almost

Type of Interruption	Value of kWh Unserved
Unplanned - Residential	$ 4
Unplanned – Other	$40
Planned - Resdiential	$ 2
Planned - Other	$20
Planned - Average	$ 4

Aurora planning parameters for lost load universally at a zone substation and sub-transmission level. Aurora uses the n-1 criteria as a screening tool to identify which parts of its sub-transmission and zone substation network require the application of probabilistic analysis to determine the most economic time to upgrade assets. Probabilistic analysis calculates an annual cost of energy not supplied for the selected network configuration. Upgrades will proceed when the net present value of the energy not supplied is greater than the cost of the upgrade.

The value used for energy not supplied is $4/kWh for domestic load and $40/kWh for nondomestic load. Probabilistic analysis is also applied at the HV feeder level. The trigger for analysis is when it is not possible to fully off-load a feeder onto adjacent feeders at peak load times or the feeder has reached 85% of its thermal rating. On rural feeders, it is normally the voltage drop that will determine the maximum capacity of a feeder not its thermal capacity.

In Dunedin, once every 5 to 10 years there is an extreme cold weather event. This will generally be a three-day snowfall that occurs during the week outside the school holiday period. These events can add an additional 20MW to the Dunedin peak demand. Aurora has determined that it is not economical to install additional assets to maintain normal supply security levels during these infrequent events so load forecasts are based on“normal” weather conditions.

The **n-1 capacity** is the maximum load a substation can supply in the event of the failure of any one item of substation equipment without the need to transfer any load from the substation.

The **Firm capacity** is the maximum load a substation can carry with the largest transformer out of service and up to 6MVA of load transfer to adjacent substations. It will generally take at least an hour to transfer load from the zone substation. During this hour the in service transformer and associated equipment must be capable of carrying the allocated firm capacity. Where the load limitation is HV switchgear that has no overload capability the firm load is restricted to the same as the n-1 load.

Frankton GXP

Transpower has allocated a 24 hour post contingency rating of 41MVA to the Frankton 110/33kV transformers. The 2005 peak load on the Frankton GXP was 40.2MW (41.02MVA @ 0.98 power factor (pf) excluding embedded generation). If the demand on the Frankton GXP exceeds 41MVA at any time, then, under the Electricity Governance System Operator policy rules, Aurora will be required to reduce load below 41MVA.

Aurora is presently negotiating a new investment agreement with Transpower to upgrade the transformers to 80MVA units. It is desirable the upgrade be completed for the winter of 2007 but delays in finalising an agreement with Transpower are making it likely the upgrade will not be completed until 2008.

Cromwell GXP

The Cromwell GXP “tees off” the Transpower 220kV lines that run between Twizel and Clyde. Two three-winding transformers supply both the 33kV to the Cromwell GXP and the 110kV supply to the Frankton GXP. The transformers are rated as 85/50/35MVA for their 220kV, 110kV and 33kV windings respectively. At present these transformers are allocated a post contingency 220kV rating of 70MVA by Transpower due to protection constraints. Transpower has indicated that up to $300,000 of work will be required to eliminate this constraint. The 2005 combined Cromwell and Frankton demand was approximately 65MVA. If the combined load grows at 4% per annum the 70MVA limit will be exceeded during the winter of 2009.

Halfway Bush GXP

The 2005 peak demand on the Halfway Bush GXP exceeded its firm n-1 capacity by 11.9MW but it should be noted that Trustpower were only injecting 3.9MW into the 33kV network at this time. Long term it is planned to move the Neville Street substation load to the South Dunedin GXP when the Neville Street gas cables require replacement. This will reduce the demand on HWB by approximately 13MVA. In the short term should the Transpower 100MVA transformer at HWB fail, Trustpower would be asked to increase their 33kV generation up to 44MW during peak periods, and up to 5MW would be transferred to the South Dunedin GXP via the 6.6kV network.

Frankton to Queenstown

The n-1 capacity of the 33kV sub-transmission from the Frankton GXP to Queenstown is constrained by the 33kV cables into the Queenstown substation. Two options to resolve this constraint are to upgrade the 33kV cables or install a new substation in the Commonage area on Queenstown Hill upstream of the cables. The new Commonage substation is presently the preferred solution.

Wakatipu Basin 33kV Ring

The Wakatipu Basin 33kV ring supplies the Dalefield, Arrowtown, Coronet and Remarkables substations and will supply the future Morven Ferry substation. The ring is run open at Arrowtown. The present system is not constrained but with further growth a section of 33kV cable into Arrowtown substation (113m of 50mm²) will constrain the contingent capacity to Arrowtown. It is proposed that this cable be increased to 95mm² at an estimated cost of $40,000.

Queenstown, Commonage and Fernhill

These substations are allocated a firm capacity equal to their n-1 rating. Load can be transferred between them but the total load that can be supplied by the three substations is constrained by the 33kV sub-transmission system.

Risk Analysis

Aurora must manage risks imposed by technological change, economic alternatives, load changes and embedded generation. These are addressed by reducing the design life of assets likely to be bypassed and addressing maintenance expenditure accordingly. All new projects or extensions are considered and proceed only if revenue security is obtained.

Another external review is planned in 2006/07 focusing on reliability issues. Reader feedback to what they believe to be appropriate reliability parameters would be appreciated.

During the flash floods in Dunedin in early February 2005, five underground distribution substations were flooded. A review has been completed and remedial works to make the vaults more watertight is programmed to be completed over the next three years on a priority basis. Remedial works to one substation are complete and works for the second substation are being planned.

Supply Performance

Supply availability and reliability to zone substations is dependent upon both the security of supply from the five Grid Exit Points within the network areas and the security and level of embedded generation connected into those Grid Exit Point systems.

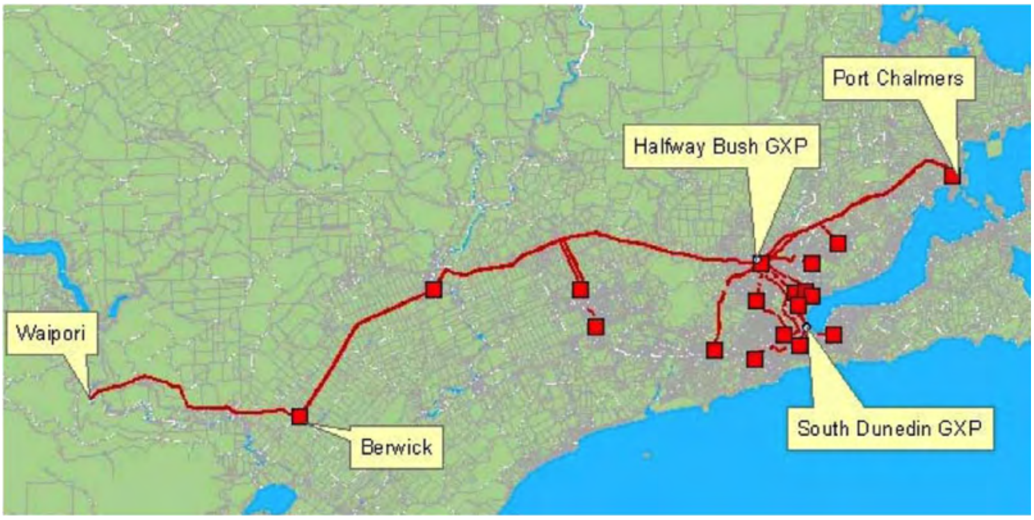
Halfway Bush does not have n-1 security unless there is significant Waipori generation.

Contingency Plans

DELTA has developed general contingency plans to assist in the timely restoration of supply following an outage to a major distribution feeder or zone substation. These are recorded in QP 1602/21. It should be noted that it is not possible to offload peak loads at most substations for an “n-2” event such as switchboard failure. This was never considered to be economic – however comment is invited regarding the desirability of this situation.

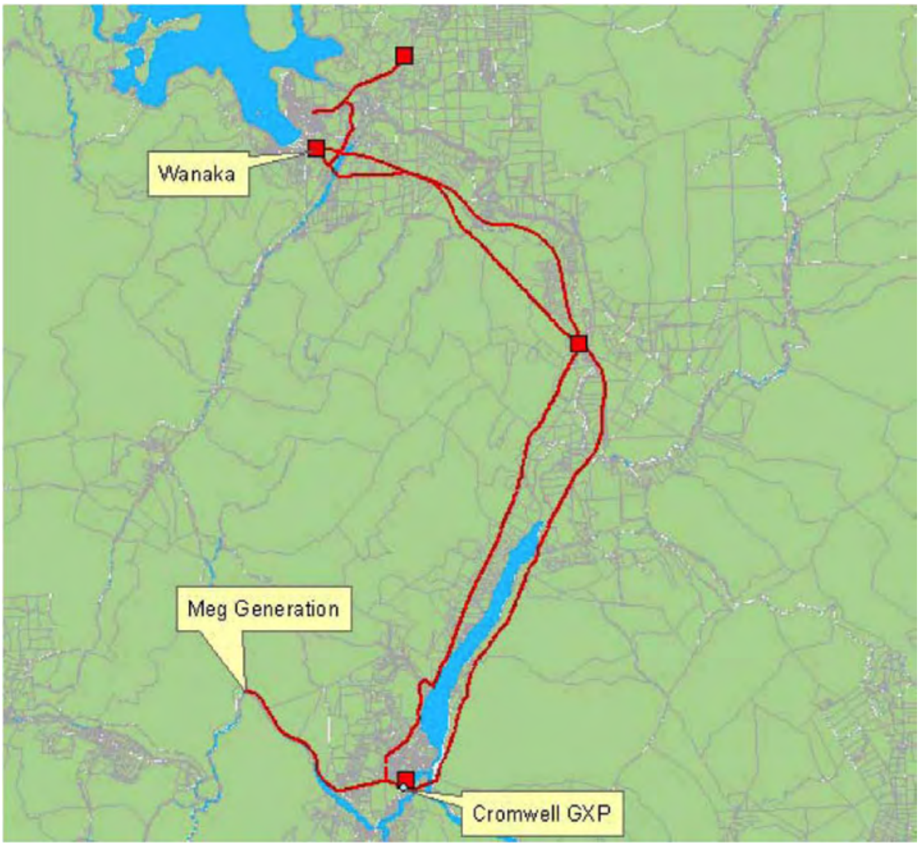
	n-1 Transpower Capacity MVA	Embedded Generation MW	Expected Controlled Load Demand 2006 MW	n-1 Security
Halfway Bush	144	44	127.2	No
South Dunedin	100	-	66.8	Yes
Clyde	60	17	17.5	Yes
Frankton	38	2	41.8	No
Cromwell	30	4	25.5	Yes

Summary of GXP security

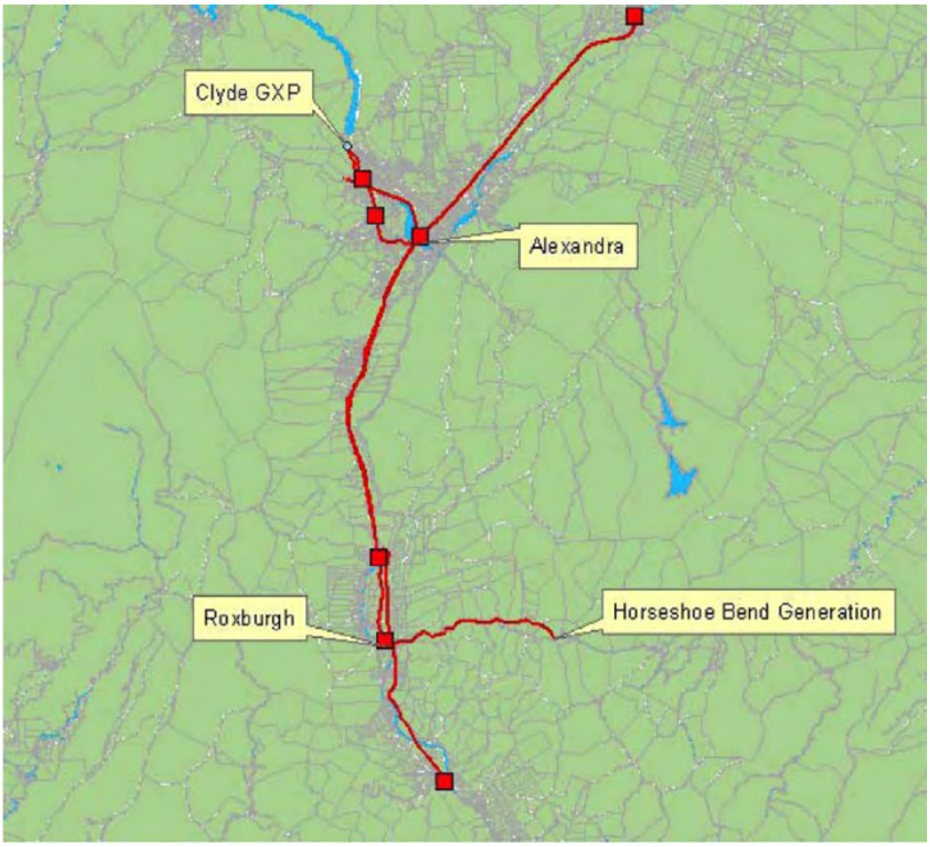


Dunedin Sub-transmission Network

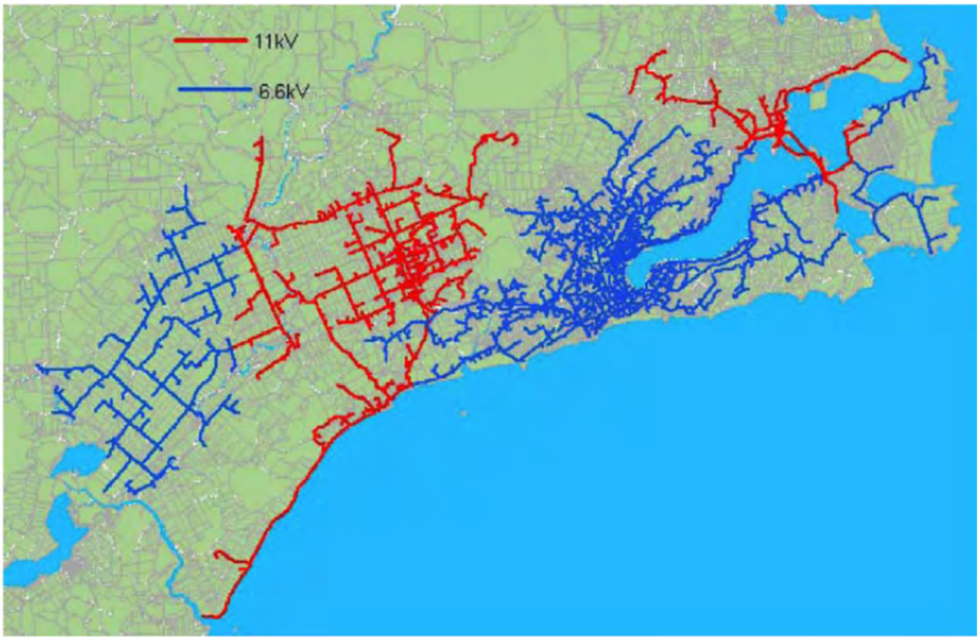
Frankton Sub-transmission Network



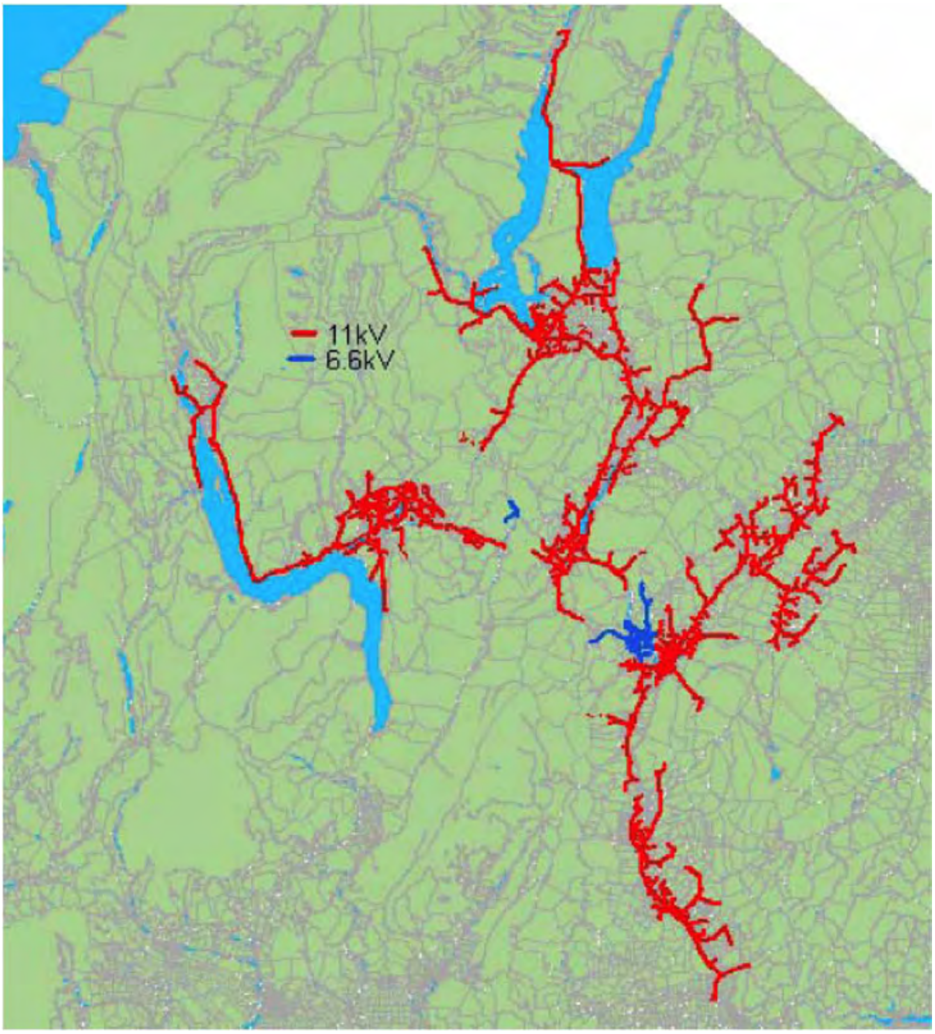
Cromwell Sub-transmission Network



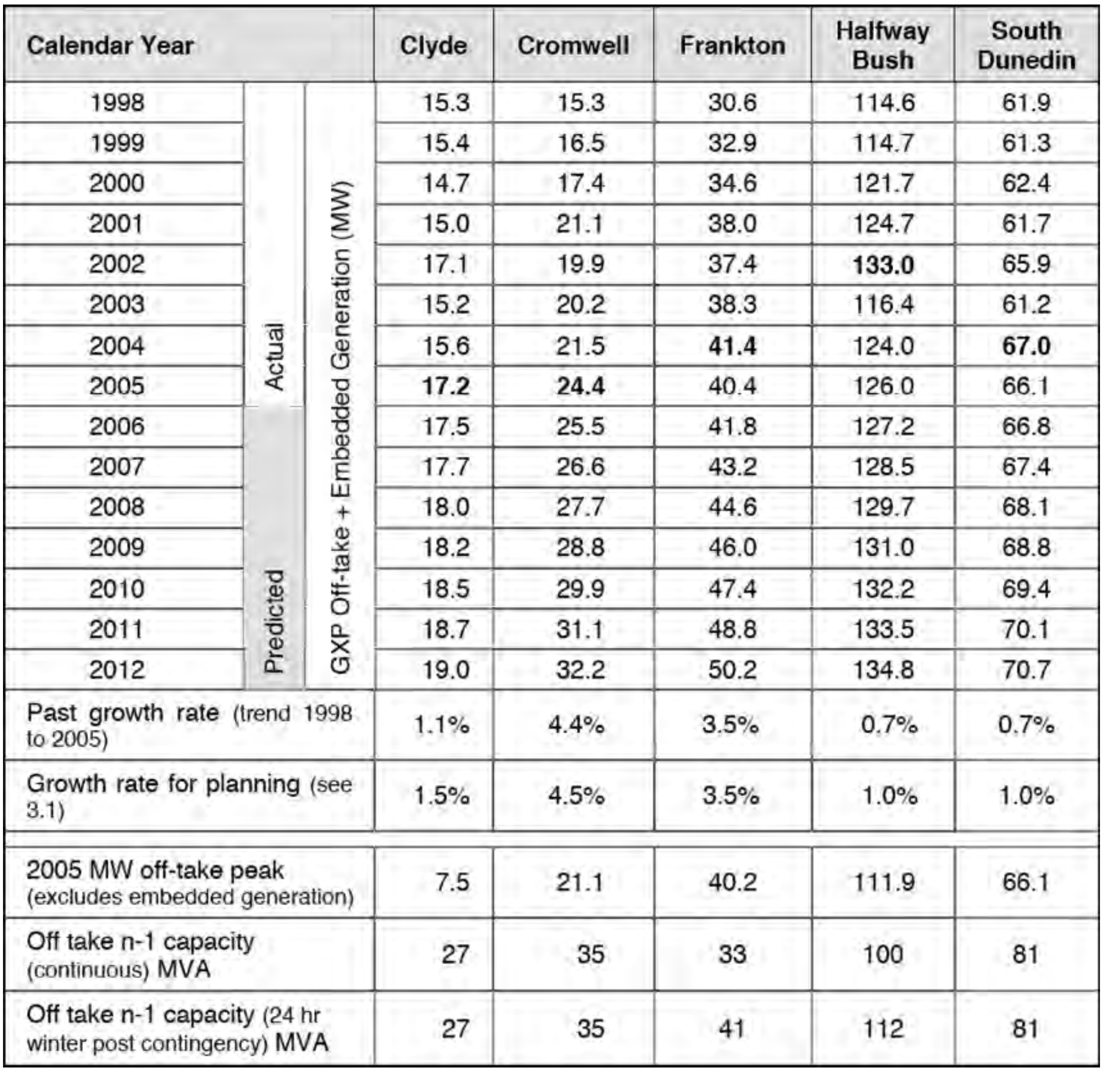
Clyde Sub-transmission Network



Dunedin HV Distribution Network



Central HV Distribution Network



Calendar Year			Clyde	Cromwell	Frankton	Halfway Bush	South Dunedin
1998	Actual	GXP Off-take + Embedded Generation (MW)	15.3	15.3	30.6	114.6	61.9
1999			15.4	16.5	32.9	114.7	61.3
2000			14.7	17.4	34.6	121.7	62.4
2001			15.0	21.1	38.0	124.7	61.7
2002			17.1	19.9	37.4	**133.0**	65.9
2003			15.2	20.2	38.3	116.4	61.2
2004			15.6	21.5	**41.4**	124.0	**67.0**
2005			**17.2**	**24.4**	40.4	126.0	66.1
2006	Predicted		17.5	25.5	41.8	127.2	66.8
2007			17.7	26.6	43.2	128.5	67.4
2008			18.0	27.7	44.6	129.7	68.1
2009			18.2	28.8	46.0	131.0	68.8
2010			18.5	29.9	47.4	132.2	69.4
2011			18.7	31.1	48.8	133.5	70.1
2012			19.0	32.2	50.2	134.8	70.7
Past growth rate (trend 1998 to 2005)			1.1%	4.4%	3.5%	0.7%	0.7%
Growth rate for planning (see 3.1)			1.5%	4.5%	3.5%	1.0%	1.0%
2005 MW off-take peak (excludes embedded generation)			7.5	21.1	40.2	111.9	66.1
Off take n-1 capacity (continuous) MVA			27	35	33	100	81
Off take n-1 capacity (24 hr winter post contingency) MVA			27	35	41	112	81

GXP demand forecast and current security settings

OtagoNet Network Security – Extract from the 2005 Asset Management Plan

The main risks to reliability are associated with the 11kV switchboards and transformers in zone substations, particularly those with only one transformer and little interconnection. The Transpower Palmerston 33kV supply is also only fed by a single transformer and 33kV bus. Other risks are a large local earthquake and weather events affecting the long radial 11kV lines.

No distributed generation has been installed on the network to date and whilst every endeavour would be made to accommodate such, depending on the location and capacity of any proposed generation, significant upgrade to the network may be required.

There have been concerns about the loads on both Balclutha and Naseby, as they are now greater than the N-1 rating, with loads of 25.7 and 24.3MVA respectively and therefore exceed the 20MVA rating of a single transformer. In Naseby this risk is reduced by the presence of the Paerau generators which mainly keep the Transpower offtake below 20MVA. At Balclutha, because there is no embedded generation and only limited ability to control the load, the risk was considered unacceptable and a contract has been signed with Transpower to replace the 20MVA transformers with two 30MVA units.

The Palmerston point of supply is a single 10MVA transformer bank supplied from two 110kV lines from Halfway Bush. Only one line is in service at any one time and switching between the lines is carried out manually at Palmerston. A single 33kV bus and no bus section switch makes this point of supply inadequate insofar that Transpower faults and maintenance shutdowns are not satisfactory for most of the 3,000 customers.

Naseby

The area supplied through the Naseby point of supply is the Maniototo region of North Otago. Naseby supplies Ranfurly through a double circuit 33kV line and at Ranfurly there are step-up transformers to 66kV, the lines from which link Macraes Mine and the Paerau Hydro Scheme. From Ranfurly there are 33kV radial lines to Wedderburn and Oturehua to the northwest and Waipiata, Hyde, Deepdell to the southeast. At Deepdell there is a tie to a 33kV line from Palmerston and then the 33kV line supplies Middlemarch, Clarks Junction and Hindon. There is also a 33kV line going southwest through Patearoa to Paerau.

The whole network is basically radial so that faults on one leg of each branch will cause a loss of supply to all customers along the branch with a supply security based on repair time. There is no adequate 11kV backup to any of the zone substations supplied from Naseby and the only 33kV backup is from Palmerston through Deepdell to Hyde, Waipiata and on to Ranfurly. There is inadequate capacity in this line to pick up any more than half the maximum loads supplied from Ranfurly.

Palmerston

The area supplied from the Palmerston Transpower point of supply is the northern coastal Otago. From the Palmerston grid supply point a 33kV line extends to Deepdell where it ties into the 33kV line from Ranfurly. To the south east there is a single circuit line through to Waikouaiti and Waitati. At Palmerston there is a single circuit line to the Palmerston zone substation, which is approximately 2.5 kilometres from the grid supply point.

Palmerston, Merton and Waitati zone substations do not fully comply with the Company's security policy in that there is only one 33kV circuit and inadequate alternative 11kV supply into Waikouaiti.

Balclutha

The area supplied from the Balclutha point of supply is mainly South Otago including the Balclutha and Milton areas. The supplies to the two major customers, PPCS Finegand Freezing Works and the Fonterra Stirling Cheese Factory, both have alternative 33kV supplies or sufficient backup through the 11kV system to comply with the Company's security policy.

The zone substations at Balclutha, Charlotte Street, Pukeawa, Lawrence, Glenore and Elderlee Street are on 33kV rings and the zone substations comply with the security policy.

The two radial lines from Lawrence to

Mahinerangi and from Elderlee Street to Waihola comply with the security policy, likewise the Clydevale and Clinton lines, however the increase in dairy farming in these last two areas will necessitate the need to provide further ties between and around the Clinton and Clydevale zone substations to satisfy the dairy customers. One 11kV enhancement between these substations is due for completion by the end of March 2006. Owaka does not currently meet the Company's security policy, but it is a difficult and remote area to establish a backup line.

Two new customers are being established in the Milburn area in the next year. One is the Corrections Department facility for 300-500 inmates with its particular security and reliability requirements, the other customer is a timber mill with a large future load increase predicted if the timber market allows. The addition of these new customers and the existing customers mean that the 11kV supply from Elderlee Street in Milton, 6 km to the south, is inadequate. A new zone substation is to be built in Milburn by the end of 2006. This will initially be a single 5 MVA transformer substation with provision for dual transformers if the predicted load growth eventuates.

With the additional load in Milburn area, the 33kV lines from Transpower Balclutha will no longer provide N-1 supply for a fault on the heavy line. It is planned to build a new heavy 33kV line from Transpower Balclutha to Milton, this together with the existing lines will provide true N-1 availability into the foreseeable future.

Distribution

The 11kV distribution network has only a low degree of interconnection between some zone substations. The lines are mostly radial, reducing in size towards the feeder ends, often ending up in light two-wire circuits or single wire earth return systems. The Clarks and Hindon area exclusively uses 22kV single wire earth return from the two zone substations.

Many of the single wire earth systems are approaching or exceeding the regulation limit of 8 amps, there are also a number of quality of supply, reliability and maintenance issues on these lines. Some of these lines will be replaced with two or three wire systems, some will have the voltage increased from 6.6kV to the standard 11kV and in one case from 11kV up to 22kV.

Security Standards

The design of the network is based on the following criteria.

Palmerston – Transpower Point of Supply

The three zone substations in the Palmerston area are fed from single 33kV circuits from the Transpower point of supply, which has only a single transformer and 33kV bus arrangement, all without regulation. These single components do not allow for any failures, do not meet the guidelines and are difficult to maintain without considerable customer interruptions. This point of supply is the most expensive for OtagoNet as well as being the least reliable.

Clydevale and Clinton

These two substations do not fully meet the proposed security standard because of only one 33kV line, single 33/11kV transformers and only partial 11kV backup from the recently completed 11kV tie line.

Group Demand	Security Rating	Arrangement
>12 MW or 6000 connections	AAA	(n-1) Uninterrupted
5-12 MW or 2000 to 6000 connections	AA	25 minutes restoration time
1-5 MW	A (i)	Isolate and restore
<1 MW	A (ii)	Repair time

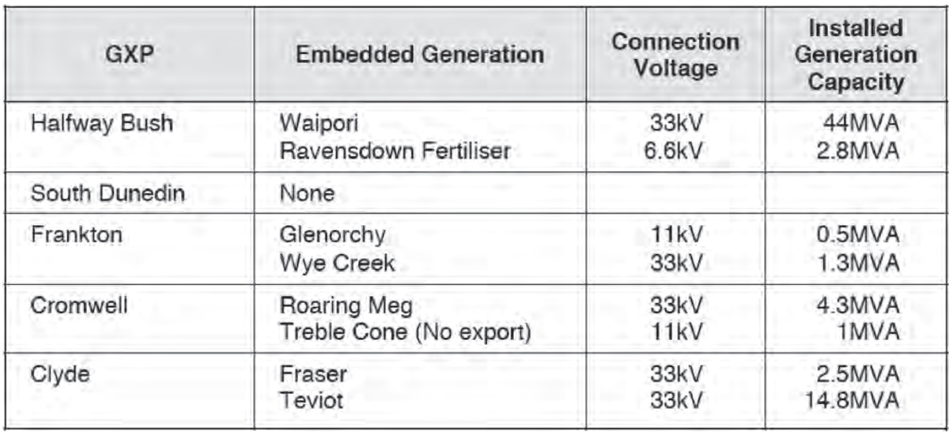
Notes:

1. Restoration time for 90% of load permits the prolonged loss of supply to individual customers following storm conditions.
2. The above table also applies in general to the distribution network, but transformers or transformer groups supplied by an underground 11kV cable and with more than 75 network connections will have a security of A(i).
3. Certain parts of the network will demand enhanced supply security due to the type of load etc.

OtagoNet security ratings

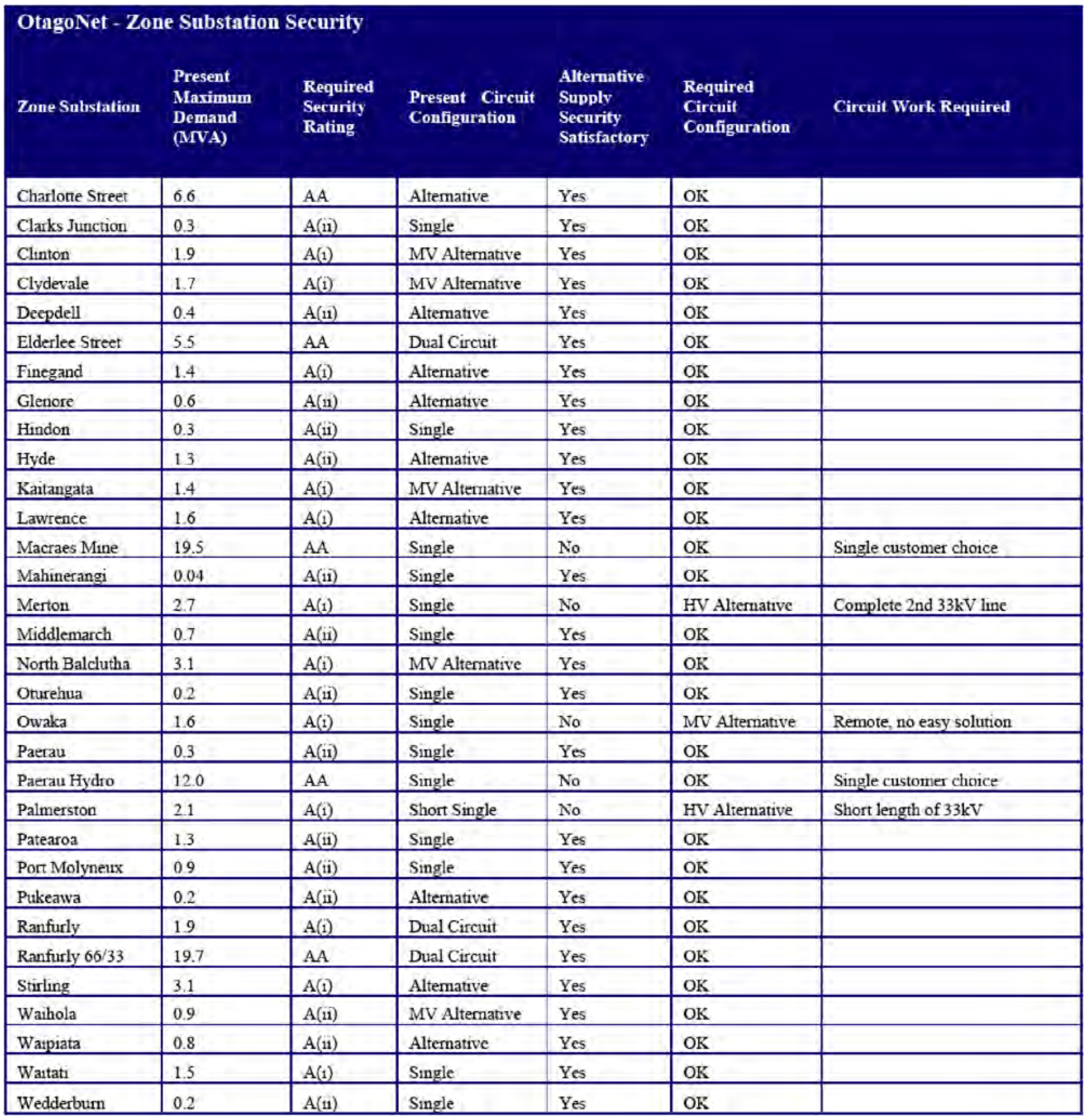
Milton Area 33kV supply

As the above projects in Milburn are proceeding, the 33kV supply into the Milton area will become inadequate in the event of a 33kV line failure. A 66kV solution was considered, but a new heavy 33kV line will provide adequate security into the foreseeable future.



GXP	Embedded Generation	Connection Voltage	Installed Generation Capacity
Halfway Bush	Waipori Ravensdown Fertiliser	33kV 6.6kV	44MVA 2.8MVA
South Dunedin	None		
Frankton	Glenorchy Wye Creek	11kV 33kV	0.5MVA 1.3MVA
Cromwell	Roaring Meg Treble Cone (No export)	33kV 11kV	4.3MVA 1MVA
Clyde	Fraser Teviot	33kV 33kV	2.5MVA 14.8MVA

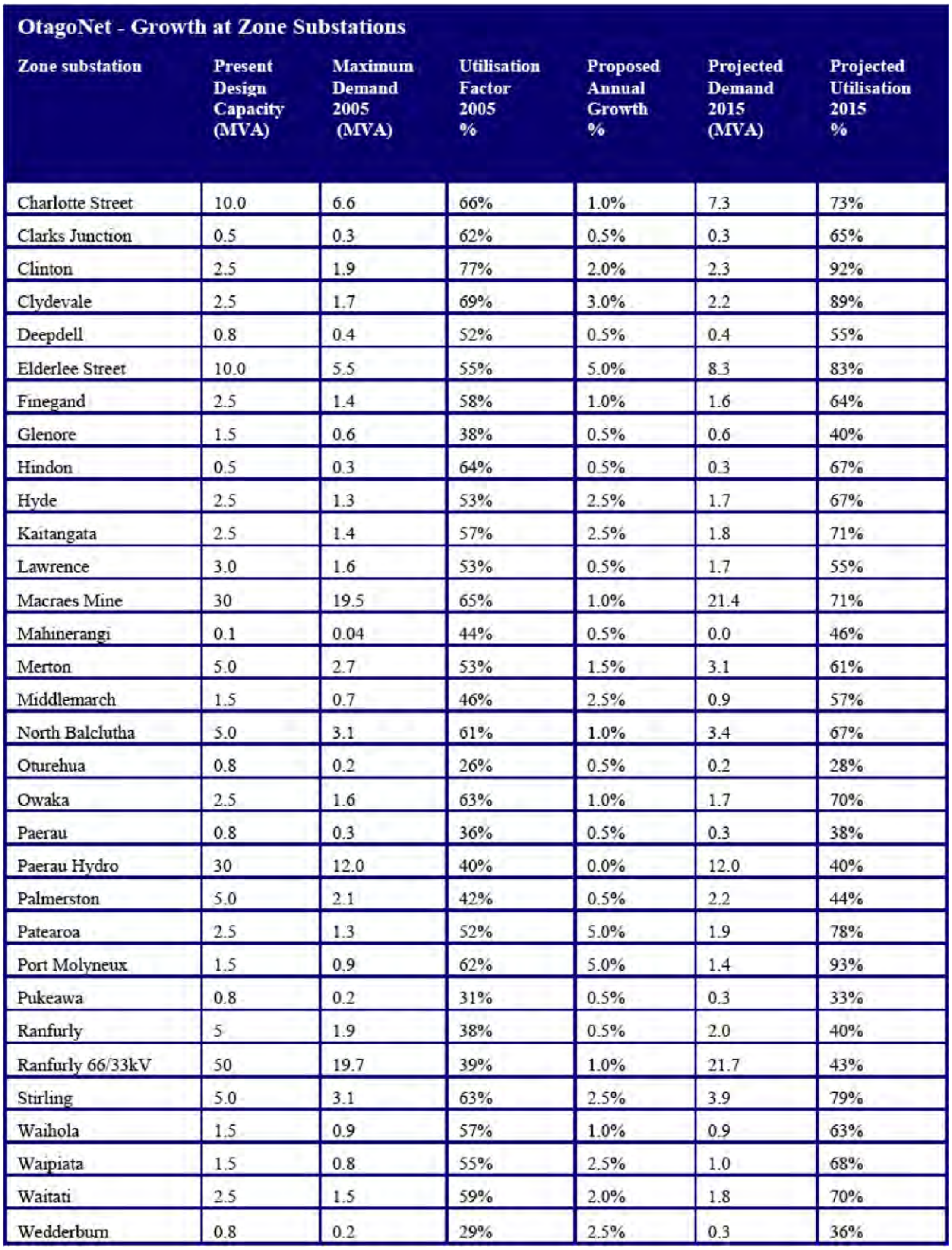
GXP supply summary



OtagoNet - Zone Substation Security

Zone Substation	Present Maximum Demand (MVA)	Required Security Rating	Present Circuit Configuration	Alternative Supply Security Satisfactory	Required Circuit Configuration	Circuit Work Required
Charlotte Street	6.6	AA	Alternative	Yes	OK	
Clarks Junction	0.3	A(ii)	Single	Yes	OK	
Clinton	1.9	A(i)	MV Alternative	Yes	OK	
Clydevale	1.7	A(i)	MV Alternative	Yes	OK	
Deepdell	0.4	A(ii)	Alternative	Yes	OK	
Elderlee Street	5.5	AA	Dual Circuit	Yes	OK	
Finegand	1.4	A(i)	Alternative	Yes	OK	
Glenore	0.6	A(ii)	Alternative	Yes	OK	
Hindon	0.3	A(ii)	Single	Yes	OK	
Hyde	1.3	A(ii)	Alternative	Yes	OK	
Kaitangata	1.4	A(i)	MV Alternative	Yes	OK	
Lawrence	1.6	A(i)	Alternative	Yes	OK	
Macraes Mine	19.5	AA	Single	No	OK	Single customer choice
Mahinerangi	0.04	A(ii)	Single	Yes	OK	
Merton	2.7	A(i)	Single	No	HV Alternative	Complete 2nd 33kV line
Middlemarch	0.7	A(ii)	Single	Yes	OK	
North Balclutha	3.1	A(i)	MV Alternative	Yes	OK	
Oturehua	0.2	A(ii)	Single	Yes	OK	
Owaka	1.6	A(i)	Single	No	MV Alternative	Remote, no easy solution
Paerau	0.3	A(ii)	Single	Yes	OK	
Paerau Hydro	12.0	AA	Single	No	OK	Single customer choice
Palmerston	2.1	A(i)	Short Single	No	HV Alternative	Short length of 33kV
Patearoa	1.3	A(ii)	Single	Yes	OK	
Port Molyneux	0.9	A(ii)	Single	Yes	OK	
Pukeawa	0.2	A(ii)	Alternative	Yes	OK	
Ranfurly	1.9	A(i)	Dual Circuit	Yes	OK	
Ranfurly 66/33	19.7	AA	Dual Circuit	Yes	OK	
Stirling	3.1	A(i)	Alternative	Yes	OK	
Waihola	0.9	A(ii)	MV Alternative	Yes	OK	
Waipiata	0.8	A(ii)	Alternative	Yes	OK	
Waitati	1.5	A(i)	Single	Yes	OK	
Wedderburn	0.2	A(ii)	Single	Yes	OK	

Zone substation security



OtagoNet - Growth at Zone Substations

Zone substation	Present Design Capacity (MVA)	Maximum Demand 2005 (MVA)	Utilisation Factor 2005 %	Proposed Annual Growth %	Projected Demand 2015 (MVA)	Projected Utilisation 2015 %
Charlotte Street	10.0	6.6	66%	1.0%	7.3	73%
Clarks Junction	0.5	0.3	62%	0.5%	0.3	65%
Clinton	2.5	1.9	77%	2.0%	2.3	92%
Clydevale	2.5	1.7	69%	3.0%	2.2	89%
Deepdell	0.8	0.4	52%	0.5%	0.4	55%
Elderlee Street	10.0	5.5	55%	5.0%	8.3	83%
Finegand	2.5	1.4	58%	1.0%	1.6	64%
Glenore	1.5	0.6	38%	0.5%	0.6	40%
Hindon	0.5	0.3	64%	0.5%	0.3	67%
Hyde	2.5	1.3	53%	2.5%	1.7	67%
Kaitangata	2.5	1.4	57%	2.5%	1.8	71%
Lawrence	3.0	1.6	53%	0.5%	1.7	55%
Macraes Mine	30	19.5	65%	1.0%	21.4	71%
Mahinerangi	0.1	0.04	44%	0.5%	0.0	46%
Merton	5.0	2.7	53%	1.5%	3.1	61%
Middlemarch	1.5	0.7	46%	2.5%	0.9	57%
North Balclutha	5.0	3.1	61%	1.0%	3.4	67%
Oturehua	0.8	0.2	26%	0.5%	0.2	28%
Owaka	2.5	1.6	63%	1.0%	1.7	70%
Paerau	0.8	0.3	36%	0.5%	0.3	38%
Paerau Hydro	30	12.0	40%	0.0%	12.0	40%
Palmerston	5.0	2.1	42%	0.5%	2.2	44%
Patearoa	2.5	1.3	52%	5.0%	1.9	78%
Port Molyneux	1.5	0.9	62%	5.0%	1.4	93%
Pukeawa	0.8	0.2	31%	0.5%	0.3	33%
Ranfurly	5	1.9	38%	0.5%	2.0	40%
Ranfurly 66/33kV	50	19.7	39%	1.0%	21.7	43%
Stirling	5.0	3.1	63%	2.5%	3.9	79%
Waihola	1.5	0.9	57%	1.0%	0.9	63%
Waipiata	1.5	0.8	55%	2.5%	1.0	68%
Waitati	2.5	1.5	59%	2.0%	1.8	70%
Wedderburn	0.8	0.2	29%	2.5%	0.3	36%

Demand forecast for zone substations

Network Waitaki Security of Supply – Extract from the 2005 Asset Mngt Plan

The zone substations are all radial connected to their GXP i.e. no rings. Therefore supply restoration is dependent on 11kV interconnection between substations.

Only the main Oamaru zone substation, Chelmer Street, (supplying 30% of NWL's load) has n-1 security configuration with dual 33kV lines and transformers. Where 11kV feeders interconnect they are normally configured as open points. NWL's loadings are such that security provisions are generally focussed on switching to restore supply quickly rather than targeting nil interruption.

The five zone substations that are connected to the Waitaki POS are supplied via a single 33kV subtransmission line that interconnects the Waitaki and Twizel GXP. These substations include Kurow, which has 2 x 2MVA ONAN transformers, Otematata, which has a single 3MVA ONAN transformer, Omarama, which has a single 3MVA ONAN transformer, Ohau, which has a single 0.5MVA ONAN transformer, and Ruataniwha, which has 2 x 0.25MVA transformers.

Approximately one third of the 11kV network is 2 wire single phase and features a large amount of spur configuration limiting interconnection. This reflects the geographic remoteness of much of the network and the historical predominance of low energy intensity sheep farming.

NWL has purchased three 635kVA diesel generators to enhance its peak demand management, defer transmission upgrade, and provide additional security options.

The network has reached the limits of its design assumptions and excess capacity. With increased load and changing load demographics, significant network reconfiguration and development is required in the medium term to service changing supply requirements.

APPENDIX 7: Key Contacts

Name	Company	Contact Details	Notes
Peter Tunnicliff	Silver Fern		Decides petroleum delivery schedule from Marsden
Andrew Sheriff	Caltex Terminal	03 4773005	Also Port Coordinator
Mike Sawyers	BP Oil Terminal/NZ Oil Services “Nozzle”		50/50 owned by BP/Shell
Alan Thorn	Shell terminal manager	03 684 7067	For Timaru/Dunedin/Bluff
Gary Marsh	Fulton Hogan	03 477 6300	Bitumen
Gary Todd	Alan Poulsen Engineering	03 477 9711	Offload fuel from tankers for all oil companies
Graham Joyce	Allied Petroleum CHC	14 Mc Alpine St., Christchurch 03 348 6086	All south island Mobil distribution
Dave Bylett	Caltex	03 477 3005	Dunedin Terminal
Lindsey Divett	RD	03 453 4533	
	Farm Direct	0800 66 6626	Supply fuel to farms
Neil Moon	Shell	03 341 2614	Service station equipment expert
Marcus Manning	BP	04 49 5547	Assets manager for service stations
Peter Johnson	City Forests	03 467 7724	
Chief Executive Officer: Rodger Hancock Marketing Manager: Dave Cormack	Wenita Forest Products Limited	Otago Office: 11 Hartstonge Ave PO Box 341, Mosgiel, Phone: + 64-3-489 3234	

Coal and Wood Retailers in Dunedin

Trailblazes (1994) Ltd
19 Portsmouth Drive
Dunedin
03 477 1559

Ward's Coal and Wood
6 Wilkie Rd
Dunedin
03 455 1652

Green Island Wood and Coal Merchants
23a Alexander St
Dunedin
03 488 2334

Kai Point Coal
14 F James St
Balclutha
03 418 0030

AJ Allen (1996) Ltd
70 Anzac Ave
Dunedin
03 477 9039

A McCann Wood & Coal Merchant
39 Hilton Rd
Dunedin
03 454 3592

The Woodshed Dunedin
Kaikorai Valley Road
Dunedin
03 488 4203

Roxburgh Coal
Coal Creek
Roxburgh
03 446 8622

Fuel Oil Managers

Caltex Terminal
Andrew Sheriff (also Port Coordinator)
03 477 3005 (from Gary Todd Alan Poulsen Engineering)

BP Oil Terminal
Mike Sawyers
NZ Oil Services "Nozzle" (50/50 owned by BP/Shell) (from Gary Todd Alan Poulsen Engineering AND Neil Brown DCC)

Alan Thorn
Shell Terminal Manager for Timaru / Dunedin / Bluff 03 684 7067

Distribution Company Contacts

1) Allied Petroleum CHC
   Graham Joyce
   All South Island Mobil Distribution
   14 McAlpine Street, Christchurch
   Ph +64 3 348 6086
2) Caltex
   Dunedin Terminal
   Dave Bylett 477 3005
3) RD
   Lindsey Divett
   453 4533
4) Farm Direct (supply fuel to farms)
   0800 66 6626

Tank Size Contact Details

We have data from DCC on permitted holding tanks and locations in Dunedin, but no values for volume.

Actual tank sizes, if needed, are likely to be obtained from:

Neil Moon
Shell Service Station Equipment Expert (worldwide)
03 341 2614

Marcus Manning
BP Assets Manager for Service Stations
04 49 5547