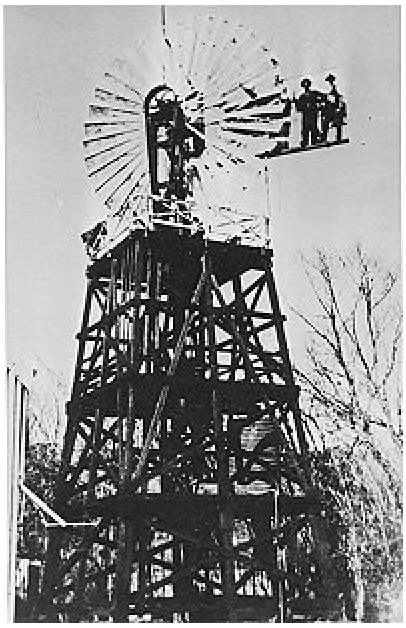
Southland Regional Energy Assessment

Appendices



Contents

Appendix 1

Regional Demographics

A1.1 Population

The assessment of future energy demand is presented in terms of business as usual scenarios, with separate identification of possible energy demands that could arise from a large industrial processor locating in Southland. The business as usual assessments have been based on the economic growth study by Butcher and the work undertaken by the Regional Water Study. To test the sensitivity of the results these are based on a conservative and an optimistic scenario.

There are currently 42,000 residential customers in the region. 11,300 are in rural areas and 30,700 in urban areas. From 1996-2001 the population declined by 6.3% similarly across all three territorial authorities[1]. The total of dwellings has increased slightly over the period while there has been a slight decline in average household size with an increase in vacancy rate (10.6% of houses are vacant cf 9.7% nationally). Since that period there has been a turn around in the Southland economy. Business and consumer confidence has risen sharply. Economic growth is probably driven by growth in returns to traditional farming, conversion to dairying, and the boost through growth in student numbers. The average unemployment rate in the year to September 2001 was 3.6% which is the lowest rate of any region in New Zealand and less than two thirds of the national average.

For base line analysis it is assumed that growth in residential electricity consumption will be at 1-2%. This also reflects the increase in electricity use through greater use of electrical appliances and equipment.

The continued economic growth throughout Southland will occur at a time when there are major technological changes within each production sector. These technology changes tend to not only increase energy demand but require higher levels of reliability and quality of supply.

There is a general shortage of skilled technicians in all trades. As the regional (and national economy) increases the use of electronic equipment there will be a greater need to have suitably trained people available. Already there are shortages of trained plumbers and other trades. Unless addressed the shortage of trades trained people will be a significant barrier to changes in energy utilisation within the region. As this is a national phenomenon this provides an opportunity for the training of Southland’s people for employment throughout New Zealand.

A1.2 Farm and Farm Processing

Growth in dairying is expected, with growth to a much lesser extent in other farming to the period to 2016. This will also reflect in an increase in dairy processing.

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[1] Butcher, G, Potential Changes in Industry and Employment in Southland Region 2001 – 2016, February 2002.

Butcher provides predictions of expected land use changes out to 2016 as shown in table A1.1.

	2001	2005	2010	2016
Forestry	73,800	79,800	87,300	96,300
Arable	8,400	8,400	8,400	8,400
Dairy	80,800	102,150	115,275	131,025
Deer	66,426	80,741	103,048	138,094
Beef	102,500	102,500	102,500	102,500
Sheep	897,506	855,841	812,909	753,113
Total	1,229,432	1,229,432	1,229,432	1,229,432

Butcher

Table A1.1 Land Use Area Predictions 2001 - 2016 (Ha)

It is expected that the attractiveness of Southland as a new dairy area will continue on the back of its favourable dairying climate and the relatively low value of land compared to land in other areas where conversion is an option. Butcher assumes that conversion will continue at approximately 15 properties per year for the next few years at least. Butcher also assumes an on-going 3% annual productivity growth on all dairy properties.

Butcher assumes that beef farming will remain static while sheep farming will continue to increase at approximately 3% per annum despite reductions in area farmed.

Overall Farming Production predictions are shown in Table A1.2.

	2001	2005	2010	2016
Kg Milksolids	70,296,000	100,024,531	130,854,724	177,595,432
Venison (hd)	148,129	202,650	299,833	479,776
Velvet (kg)	192,634	263,536	389,917	623,924
Prime cattle (hd)	271,625	305,716	354,409	423,183
Cow (hd)	148,129	271,625	8,642,986	56,504,647
Lambs (hd)	8,642,986	9,276,163	10,214,174	11,299,123
Mutton (hd)	1,768,088	1,897,616	2,089,504	2,311,451
Wood (kg)	52,647,724	56,504,647	62,218,429	68,827,265

Butcher

Table A1.2 Primary Industry Output Predictions

There are seven facilities that process sheep and cattle. These vary from large multi-chain export works to local abattoirs.

The Edendale dairy factory has recently expanded production and it can be expected that further growth will occur on the site.

A1.3 Wood Processing

There will probably be a decline in forestry (silviculture, harvesting and management) over the forecasting period, partly because the wood harvest volume in Southland is likely to decline slightly and also because of the shift towards Douglas fir and eucalyptus, which will have low input tending regimes. Beyond 2016 there is a significant growth in log production.

The volumes of timber likely to be produced over the next 15 years have been estimated by the Otago and Southland Forest Products Group and are shown in table A1.3.

	Corporate	Private	Total	
			Annual	**3 Year Ave**
1999	500	150	650	
2000	500	386	886	751
2001	500	216	716	818
2002	500	351	851	763
2003	460	262	722	736
2004	385	251	636	585
2005	207	189	396	486
2006	358	67	425	482
2007	454	170	624	554
2008	508	105	613	677
2009	637	156	793	772
2010	579	330	909	764
2011	453	136	589	696
2012	547	42	589	632
2013	593	126	719	666
2014	629	60	689	723
2015	730	32	762	697
2016	570	70	640	742
2020	730	1214	1944	----

Source: Otago and Southland Forest Industries Profile. Otago Southland Forest Products Inc, Jan 2002

Table A1.3 Forecast Volumes (m^3) of Timber Produced per Annum

Further growth in wood processing is expected however the region is short of wood and currently imports wood from North Otago where there will be rapid increases in log volumes over the next 10 years. Further growth in wood processing in Southland is possible over the medium term but it is assumed to be additional processing to higher value products on existing sites. The high quality of Southland wood (very white colour) makes it particularly suitable for further processing.

A1.4 Tourism

Tourism and education are likely to continue to be growth areas for Southland.

Growth in regional visitor accommodation is predicted to grow from $53million in 2001, to $67 million in 2006, $86 million in 2011 and $111 million in 2016.

A1.5 Manufacturing

Butcher provides no guide to manufacturing growth but makes the point that the trend towards centralisation of production to take advantage of economies of scale and of aggregation means that it is difficult for regions on the periphery to grow new industries. To change this situation Southland must attract new entrepreneurs to the region.

Comalco indicate that despite being affected by high energy costs that they intend staying in the region. A more attractive electricity supply could attract industry to add value to aluminium produced by Comalco by production of end use products.

The silica resource in the region could be refined if there was adequate electricity supply at an appropriate cost.

Indigenous energy sources such as oil, gas and coal could provide additional economic growth if the region were to partner with resource owners to identify opportunities for utilisation. Building this into an energy based industry around all energy forms could provide for additional skills training particularly in the trades areas, as such skills are in short supply nationally.

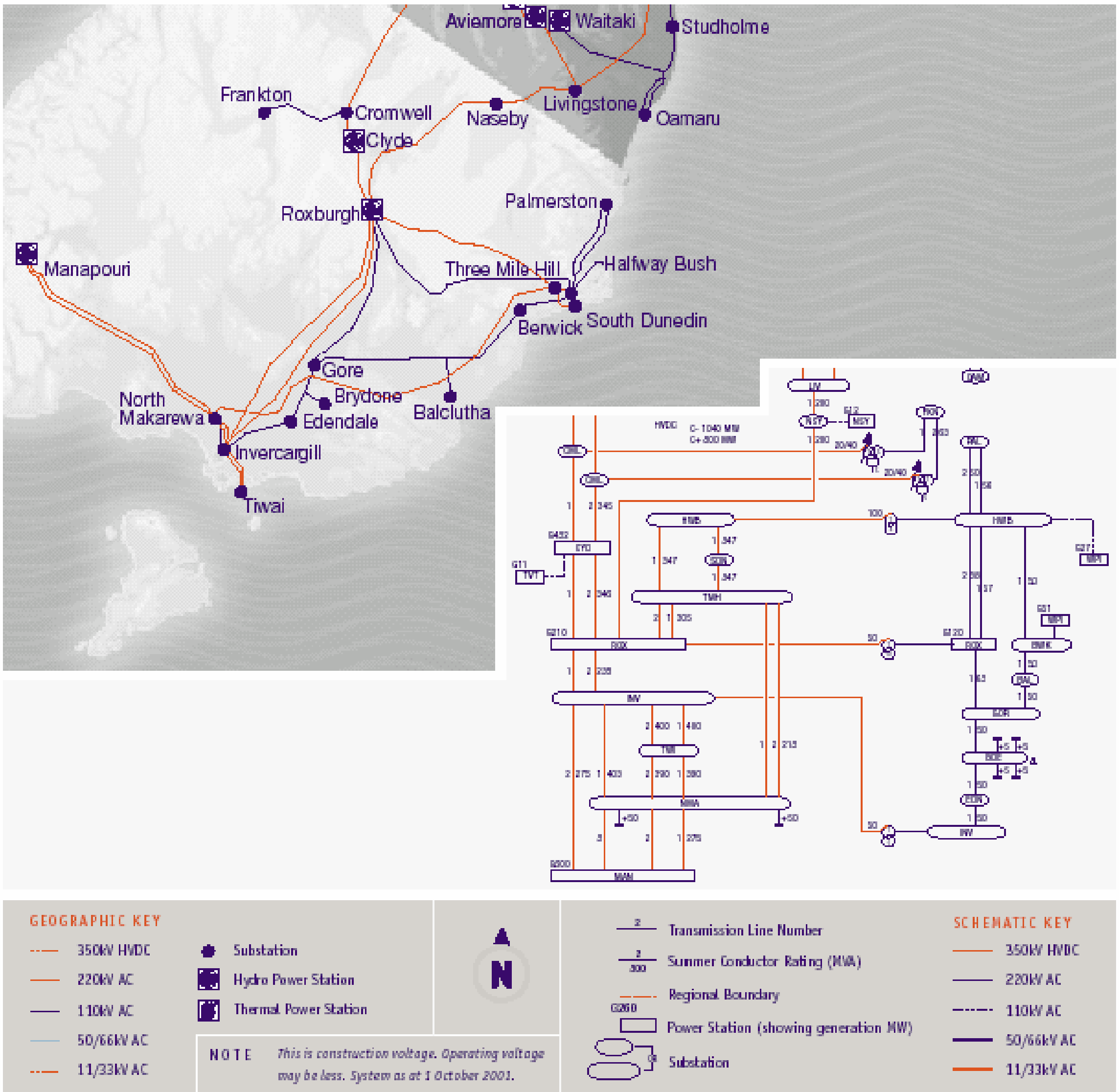
Appendix 2

Electricity Transmission / Distribution System

A2.1 Transpower Transmission System

Transmission Network

The Otago Southland region is supplied by 220kV and 110kV transmission lines with interconnecting transformers at, Halfway Bush, Roxburgh, and Invercargill. To improve the network voltage and voltage stability performance static capacitors are installed at North Makarewa substation. Figure A2.1 shows the region geographically and schematically.



Source: Transpower

Figure A2.1 Southland Electricity Transmission System

Generally the installed generation capacity is inadequate to meet local demand so electricity is imported to the region. Manapouri generation is around 660-680MW while

Comalco load is up to 610MW. However, during low load periods in Southland, if there is high generation at Manapouri, electricity may be exported.

Figure A1.3 shows the area of transmission constraint in Southland

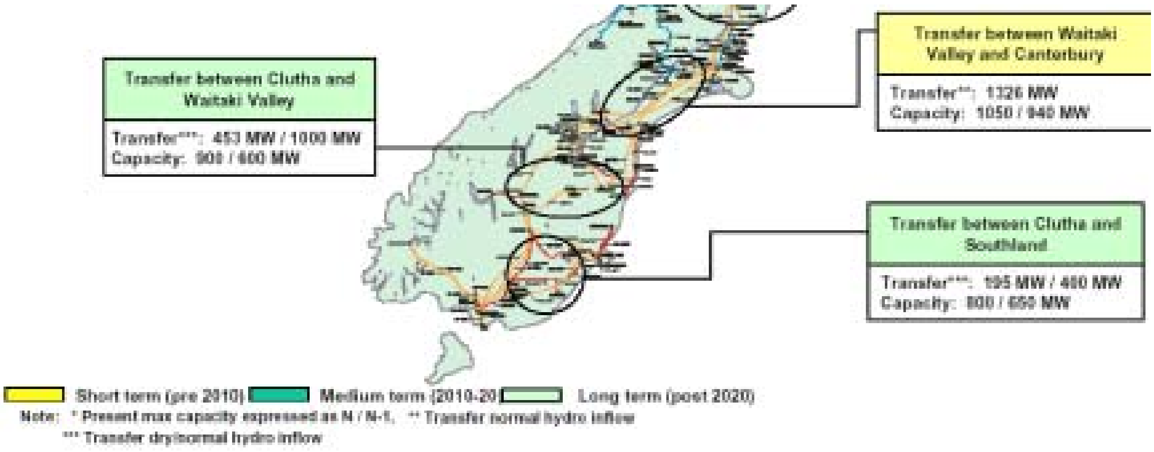


Figure A1.3 Transmission Constraints

Transpower suggests that moderate generation in the tens of MW range connected to the Southland 110kV network would be of benefit. However this generation may be constrained under some outage conditions. Supplying reactive power from the distribution network to provide voltage support to the electricity 110kV system is another opportunity.

Upgrading the transmission system throughout all of the South Island is part of Transpower's longer term plans.

Southland Transmission Constraint

Loss of 220 kV Circuit Between Invercargill and Roxburgh
When Manapouri generation is low, the two Invercargill-Roxburgh circuits are critical in supplying Southland load (including Comalco). Both circuits have summer/winter ratings of 232/286 MVA. The outage of one of the Invercargill-Roxburgh 220 kV circuits could overload the other circuit or cause voltage instability in the region depending on the generation level at Manapouri.

The voltage instability issue could be managed by running Manapouri generation for voltage support only (ie as synchronous condensers) and switching in both capacitor banks at North Makarewa. However without dynamic support from Manapouri, voltage stability would be an issue. Historically, voltage regulation has been driven by requirements at Comalco.

The loading of the remaining Invercargill-Roxburgh 220 kV circuit when the other is out of service is a function of the regional load and Manapouri generation. Figure A1.4 shows the loading on the remaining Invercargill-Roxburgh 220 kV circuit as the regional load increases for different levels of Manapouri generation. The load at Edendale, Gore, Brydone, North Makarewa, Invercargill, and Tiwai affects the circuit loading.

The following observations can be made from figure A1.4:

- With Manapouri not generating, the maximum load that can be met without overloading the remaining Invercargill-Roxburgh 220 kV circuit is 500/580 MW in summer/winter.

- The Invercargill-Roxburgh 220 kV circuits reach their summer and winter ratings when the load reaches 780 and 880 MW with Manapouri generation of 300 MW. The load that can be supplied is clearly dependent on Manapouri generation.
- Load power factor has a secondary effect on the circuit loading because reactive power flows are relatively small.
- The load at Edendale, Gore, Brydone, North Makarewa, Invercargill, and Tiwai is varied because this is the critical load for this issue.

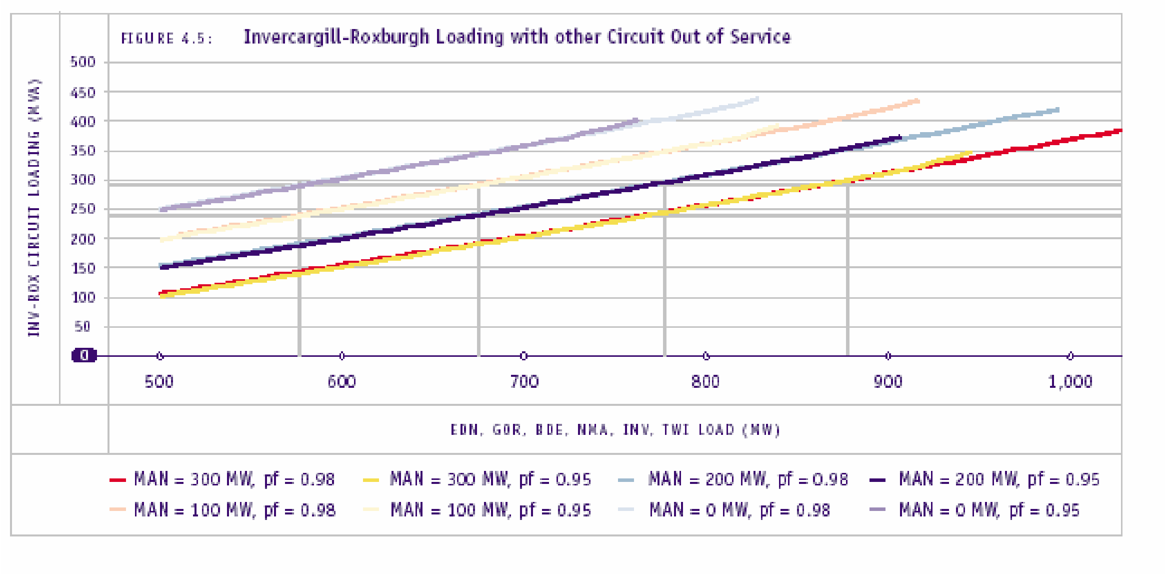


Figure A1.4 Invercargill – Roxburgh Electricty Loading

The frequency of constraints occurring is very low with an average of xxx per year.

Southland 110kV Network

The Southland 110 kV network (Halfway Bush to Invercargill) can supply the present load with all equipment in service. The load can also be supplied with one circuit out of service, albeit with some voltage issues, but significant overloads and very low voltages occur if there is an outage on a second circuit due to a fault. To date, this has been managed by limiting the load offtake during maintenance outages, which causes significant difficulties. The loss of the 220/110 kV interconnecting transformer is considered the same as the loss of a circuit

One option to manage the overload issues on the Southland 110 kV network is the installation of automatic load shedding , that sheds load after an event. This may be an appropriate solution to manage maintenance outage problems, given that load will only be shed if another circuit trips during a maintenance outage. This option has been flagged by Transpower with PowerNet.

A system-based solution would be to install an additional 220/110 kV interconnecting transformer at Gore and/or Balclutha. Load growth may eventually require this system reinforcement.

Several outages can cause overloading of the Roxburgh 220/110 kV transformer. The overload can be prevented by appropriately constraining generation at Roxburgh. At present there are no transmission proposals to remove this constraint.

Exposure to Risk

The forecast load duration curves for the combined load at the Edendale, Gore, Brydone, North Makarewa, Invercargill, and Tiwai substations are shown in figure A1.5. As noted above, this security issue is closely linked with the availability of Manapouri generation and has strong security implications for the demand south of Roxburgh, including the Tiwai Point industrial load of 575 MW.

The N-1 security limits without Manapouri generation will be exceeded almost 100 per cent of the time. Increasing minimum Manapouri generation to 300 MW will significantly resolve this issue. If generation is unavailable, the operational solution to manage the overload is through a combination of actions including through the use of short term post-contingency ratings and load management.

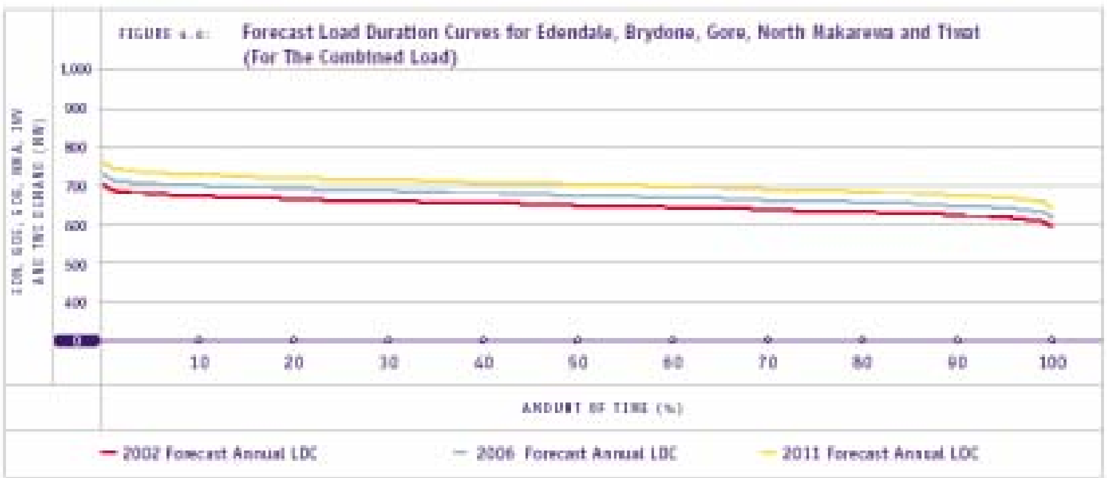


Figure A1.5 Southland Combined Electricity Load

Upgrade of Transmission System

The transmission system is already under constraint under certain situations. If a major electricity demand of around 150MW were to locate in Southland then this situation would occur more often. Transpower have been investigating upgrading the transmission system. There are two options.

Upgrade 220kV Invercargill-Roxburgh – Lines
Evaluation of the capability of the existing Invercargill-Roxburgh lines has been undertaken by Transpower , and it has been determined that the capacity of these lines can be increased.

Upgrade 220kV to 330+kV
Transpower is also evaluating upgrading sections of the 220kV network throughout the country to 330kV or above. Introduction of such an upgrade would be undertaken in stages. Currently Southland would be in a later stage, depending on the timing of when the 220 kV line limit is reached, so would not be undertaken for a number of years. In addition to providing additional transmission capacity, the 330 kV or higher voltage option will also reduce transmission losses - MW & MVAr loss.

A2.2 The Power Company Distribution System

Network

The Power Company electricity distribution network is shown in figure A2.5.

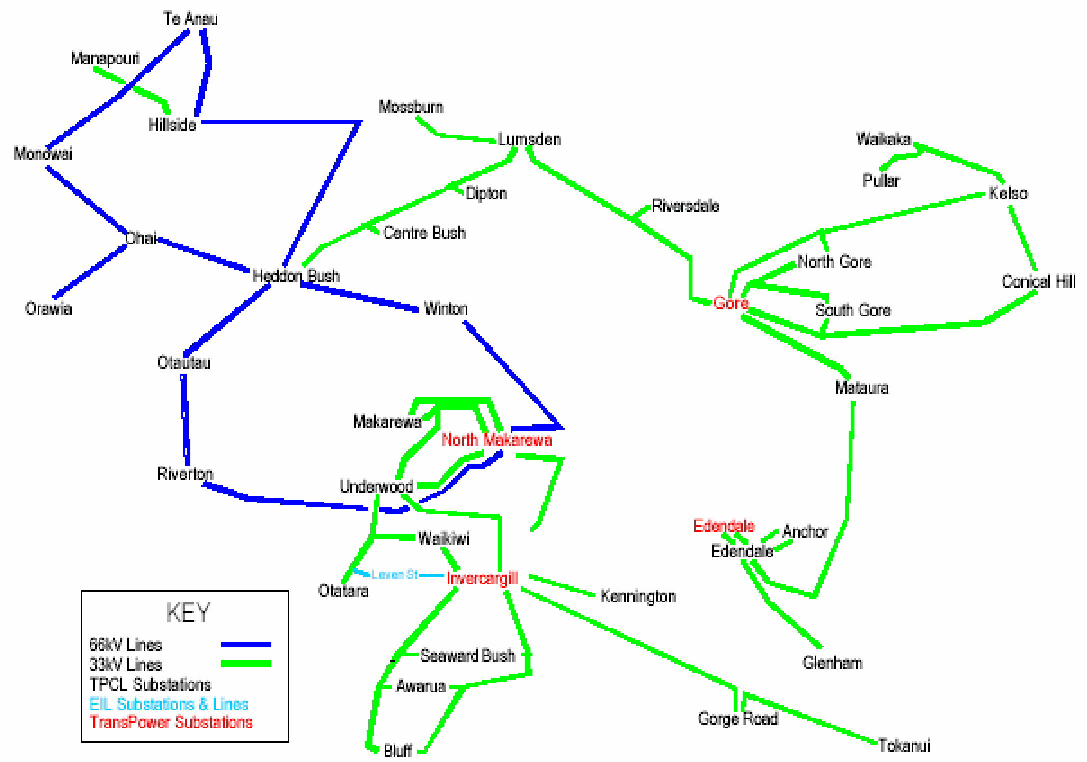


Figure A2.5 The Power Company Distribution System

Growth

Analysis of the last three years electricity supply shows that demand has been increasing at a steady 1% with limited growth over most substations. The growth over the last 20 years was 2.3% per annum.

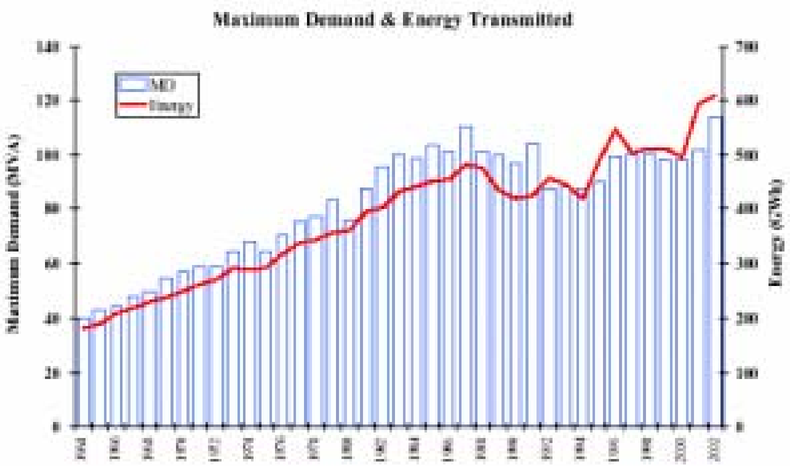


Figure A2.6 The Power Company Annual Electricity Supply

The introduction of ripple control in 1989 and its full automation in the following years is clearly shown in figure A2.6. This shows the high value ripple control has in reducing peak demand for electricity. Transpower charges are based on the 12 highest peak demands.

Reducing peak electricity demand can assist keep electricity transmission costs to the region low.

Supply Security and Reliability

Both The Power Company distribution systems are well managed and well maintained.

Supply security from Transpower satisfies The Power Company's normal requirements. Since the Transpower Brydone point of supply was established, Transpower can only supply a limited capacity through the 110kV system from Roxburgh if the 220/110kV transformer bank at Invercargill is out of service through either a fault or maintenance.

Because the Power Company system in west Southland supplied through the North Makarewa Transpower point of supply is operated as two 66kV rings this provides a high degree of security. The protection is designed to operate to disconnect any faulty section of the 66kV ring without loss of supply to other customers.

West Southland is also linked to Gore via a 33kV system. East Southland is supplied from Gore and Edendale via a 33kV system. Each part of the system has a connection to two Transpower supply points.

The 11kV distribution system has a high degree of interconnection between zone substations.

The level of faults in the distribution systems have been dropping each year since the establishment of the current organizations and management structure. The performance levels are shown in tables A2.1 – A2.4.

The Power Company Interruptions

(Number)	**Target**	**Projected**	**Actual**				
Class	**10 Year Average**	**2002/2003**	**2001/2002**	**2000/2001**	**1999/00**	**1998/99**	**1997/98**
B	156	152	194	177	424	467	545
C	339	366	375	389	488	497	545
Total	495	518	569	566	912	964	1090

Table A2.1

System Average Interruption Duration Index (SAIDI)

(Minutes)	**Target**	**Projected**	**Actual**				
Class	**10 Year Average**	**2002/2003**	**2001/2002**	**2000/2001**	**1999/00**	**1998/99**	**1997/98**
B	16.0	16.4	20.0	16.0	73.9	62.2	92.9
C	118.0	144.7	117.8	130.0	339.6	281.7	651.5
Total	134.0	161.1	137.8	146.0	405.0	343.9	744.4

Table A2.2

System Average Interruption Frequency Index (SAIFI)

(Number)	**Target**	**Projected**	**Actual**				
Class	**10 Year Average**	**2002/2003**	**2001/2002**	**2000/2001**	**1999/00**	**1998/99**	**1997/98**
B	0.11	0.10	0.14	0.13	0.56	0.56	0.79
C	2.6	2.97	2.73	2.76	5.89	5.58	6.75
Total	2.71	3.07	2.87	2.89	6.45	6.14	7.54

Table A2.3

Customer Average Interruption Duration Index (CAIDI)

(Minutes)	Target	Projected	Actual				
Class	**10 Year Average**	**2002/2003**	**2001/2002**	**2000/2001**	**1999/00**	**1998/99**	**1997/98**
B	144.5	164.4	146.8	120.5	131.9	111.0	117.6
C	45.4	48.7	43.1	47.1	577.7	50.5	96.5
Total	49.4	52.5	48.0	50.5	64.1	56.0	98.7

Table A2.4

Faults per 100 km Prescribed Voltage Line in 2002	
Electricity Invercargill Ltd	11
The Power Co	6
New Zealand (Median)	7
New Zealand (Mean)	7

Table A2.5

The Power Company has a programme of work to continually improve security and reliability of supply.

The Power Company regularly reviews operational ways in which it can obtain improved utilisation of its assets. These include;

- Transfer of load between GXPs or zone substations,
- Extended use of ripple control'
- Interactive demand management with large customers
- Incentives through line charges which encourage off peak usage of the network.

The design of the network is based on the criteria set out in table 2.5:

The Power Company Security Ratings		
Group Demand	**Security Rating**	**Arrangement**
>12 MWatts or 6,000 connections	AAA	(n-1) Uninterrupted
5-12 MWatts or 2,000 connections	AA	25 minutes restoration time
1-5 MWatts	A(i)	Isolate and Restore
<1 MWatt	A(ii)	Repair time

Table A2.6

A2.3 Electricity Invercargill Distribution System

Network

The Electricity Invercargill electricity distribution network is shown in figure A1.6. Network design criteria are the same as those for The Power Company.

Invercargill is supplied by the 220kV grid through 2 x 50MVA 33kV transformers. Supply security from Transpower satisfies PowerNet's requirements although there have been two total supply interruptions from Invercargill within the last 20 years.

The Electricity Invercargill Limited 11kV distribution network in the Invercargill City part of the network is supplied from four zone substations. These substations are Doon Street, Southern, Leven Street and Racecourse Road.

The Bluff part of the network is supplied from Bluff's zone substation which itself is supplied via two 33kV Power Company Limited owned overhead lines.

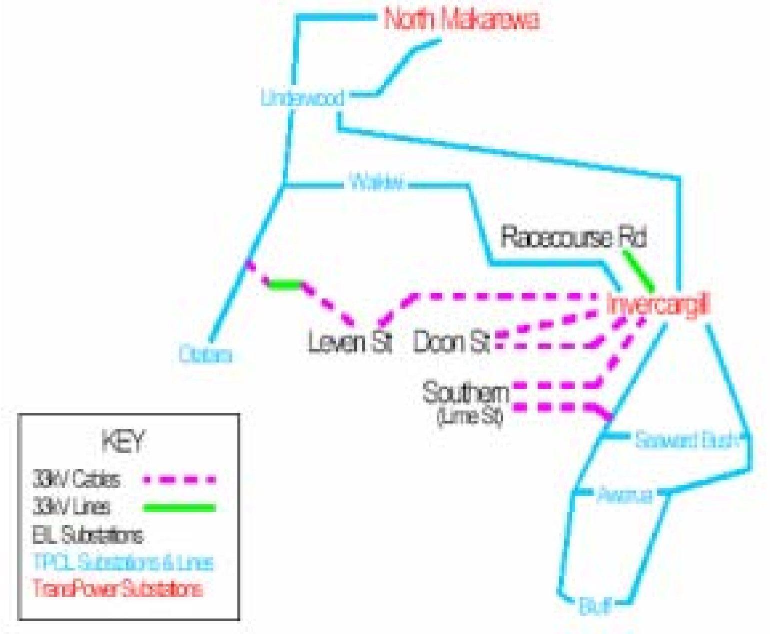


Figure A2.7 Electricity Invercargill Distribution Network

Growth

The Electricity Invercargill growth has been 0.49% per year over the last 20 years and this is expected to continue.

The graph of Annual Load Factor in figure A2.8 shows the impact of the introduction of ripple control in 1956 and the gradual increase in Off Peak Water and space heating up to 1990.

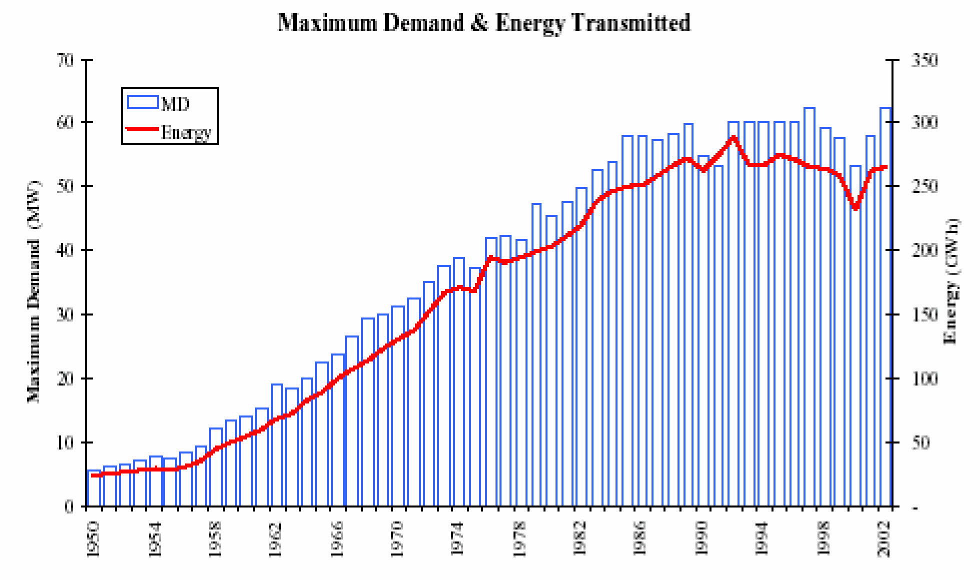


Figure A2.8 Electricity Invercargill Annual Electricity Supply

Reliabilty and Security

Improvements in the performance of the network do not always entail new investment. Operational considerations such as transfer of load between zone substations, extended use of ripple control or interactive demand side management with large customers and incentives through line charges which encourage off peak usage of the network are part of the overall strategy.

To improve operational reliability, consideration is given to the following three factors:

1. Reducing the number of faults by good maintenance and progressing the underground lines programme in the City.
2. Reducing the number of planned interruptions by increasing the use of live line working on the remaining overhead high voltage lines.
3. Reducing the impact of supply interruptions through the use of SCADA.

Electricity Invercargill

Interruptions

(Number)	**Target**	**Projected**	**Actual**				
Class	**5 Year Average**	**2002/2003**	**2001/2002**	**2000/2001**	**1999/00**	**1998/99**	**1997/98**
B	9	10	11	11	18	16	16
C	21	18	22	29	22	58	32
Total	30	28	33	40	40	52	48

Table A2.7

System Average Interruption Duration Index (SAIDI)

(Minutes)	**Target**	**Projected**	**Actual**				
Class	**5 Year Average**	**2002/2003**	**2001/2002**	**2000/2001**	**1999/00**	**1998/99**	**1997/98**
B	3.2	2.5	4.0	4.0	4.7	7.7	10.5
C	25.7	25	32.0	31.0	29.0	45.0	95.1
Total	28.9	27.5	36.0	35.0	33.7	52.7	105.6

Table A2.8

System Average Interruption Frequency Index (SAIFI)

(Number)	**Target**	**Projected**	**Actual**				
Class	**5 Year Average**	**2002/2003**	**2001/2002**	**2000/2001**	**1999/00**	**1998/99**	**1997/98**
B	0.04	0.03	0.04	0.05	0.011	0.07	0.10
C	0.92	0.80	1.12	1.07	0.53	1.34	1.23
Total	0.96	0.83	1.16	1.12	0.64	1.14	1.33

Table A2.9

Customer Average Interruption Duration Index (CAIDI)

(Minutes)	**Target**	**Projected**	**Actual**				
Class	**5 Year Average**	**2002/2003**	**2001/2002**	**2000/2001**	**1999/00**	**1998/99**	**1997/98**
B	88.0	83.3	98.8	80.4	42.5	110.3	110.3
C	28.0	31.25	28.5	28.9	54.8	34.1	77.1
Total	30.0	33.13	31.0	31.25	52.66	21.8	79.4

Table A2.10

NB: Class B are planned interruptions; Class C are unplanned interruptions due to faults.

A2.4 Distributed Generation

The network connection costs for embedded generation usually reflect the cost of network connection with a credit for the benefits embedding can provide the network for voltage support and supply security. The costs are based on peak capacity. Some network companies have posted costs which provide transparency to an installer of embedded generation. Other network companies work on a negotiated arrangement in order to identify the best win/win benefits for both parties. This latter approach adds to the transaction costs for cogeneration.

Where excess electricity is produced and is available for sale to a third party the electricity industry structure makes it difficult to find a buyer and to get a good price. At present the electricity market is dominated by electricity sector participants who have no incentive to contract with other small generators.

Appendix 3

National Energy Supply

There is a potential national energy supply gap arising between 2004 – 2008. Regardless of whether the depletion occurs in 2004 or 2008 the effect is still the same. It is only a matter of timing, and actions to be taken are required regardless of timing.

While NZ has a wide range of long-term solutions available to it many of these cannot be instituted in the time available. While the energy market has a large number of potential participants, many of whom have planned actions to manage the uncertainties surrounding projected changes in availability and price of energy, there remain significant risks of non supply from any of a number of factors.

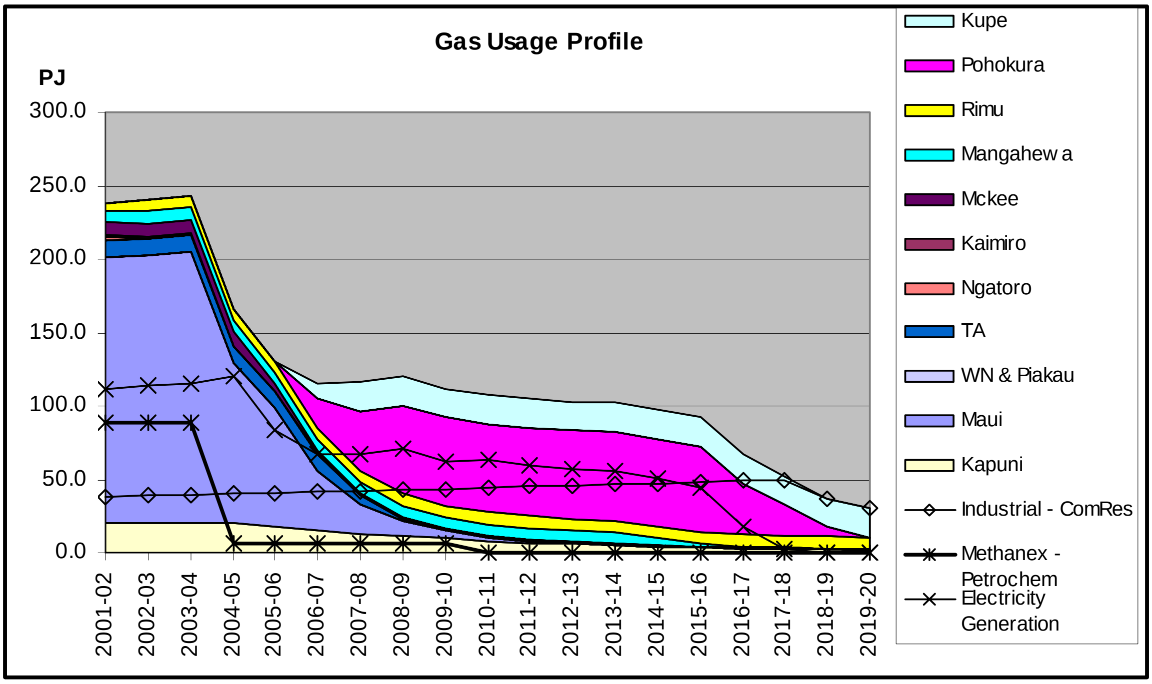
To cover the possibility of planned or possible action not eventuating in adequate time, or not at all, the energy sector is preparing short-term contingency solutions such as commissioning of Marsden B power station. Government has also taken action to provide for reserve generation to be available by the middle of 2004. The short-term actions will contribute significantly to easier implementation of the longer-term solutions. The energy market issues are as much political as technical and will require action on a number of fronts. There is no single long-term solution.

Southland energy costs are determined by what is happening elsewhere in the New Zealand energy market

A3.1 Gas

For the last two decades New Zealand has been very reliant on gas from the Maui gas field. This field is now getting to the end of its reserves. The large size of the Maui gas field has shielded and inhibited the energy market from taking actions that will now need to be taken. The size and nature of the field has previously reduced the drivers to invest in new fields or find alternative solutions. The size of Maui also provided flexibility for supply which will now have to be provided by a number of smaller gas fields, coal and other resources. This will be more difficult. The complexity of energy supply will increase but at the same time a number of opportunities that have been dormant will be assisted to emerge.

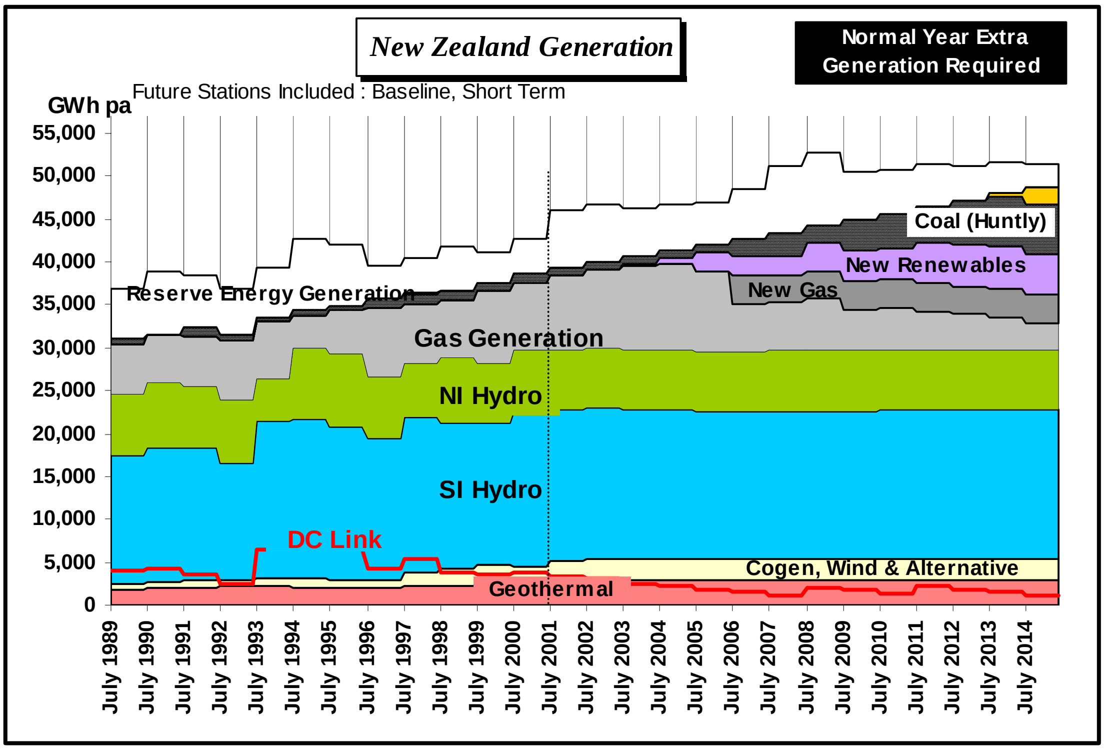
As shown in figure A3.1 substantial gas reserves are potentially available but these tend to take up to 10 years to develop. The Pohokura gas field is expected to come on stream around 2006 and the Kupe field is awaiting decisions on development. These plus other smaller fields will not however make up for a decline in Maui output. If an early decision was made on Kupe there may however be an overlap but this could be a difficult and expensive field to develop. A shutdown of Methanex, may extend gas available to generation and reticulation for a period.



Source: Ministry of Economic Development

Figure A3.1 Future Gas Reserves

A3.2 Electricity Supply



Source:Centre for Advanced Engineering

Figure A3.2 Future Electricity Generation

All scenarios of future energy supply show the surplus generation capability enjoyed over the past decade is rapidly disappearing. This is particularly noticeable in the dry year scenario where there is a significant risk of an electricity supply shortage. The depletion of Maui will increase supply risks in serious dry years. Figure A3.2 shows a typical scenario of possible future electricity supply.

Under normal hydro conditions Transpower forecast electricity generation capacity is projected to exceed demand until 2010 with a deficit occurring in 2011. However when spinning reserve and units out for maintenance are taken into account a deficit occurs in 2006 for the high and medium scenarios and 2008 for the low scenario.

A3.3 Electricity - Dry Year Risk

Because the electricity market is hydro-dominated the potential for dry year shortfalls can be very significant for the availability and price of electricity. Over the last few years 900 MW of peaking electricity generation capacity has been withdrawn from service. The result is that NZ now has a very thin capacity margin to meet dry year shortfalls.

As has been experienced during 2001 and 2003, dry years can come quite frequently and they are very disruptive to industrial production. During each of these dry years the energy companies took decisive action to manage demand. However even today few electricity industry participants have demand response mechanisms available that could be brought into action at short notice. The actions taken by the whole country are short lived, and other than Government led initiatives such as construction of reserve generation, little has been done by the energy sector to prepare for the next dry year.

A3.4 Energy Prices

Related to but more important than concerns about physical supply of energy is its price, as this affects our international competitiveness.

With the decline of delivery of gas from the Maui gas field, gas prices are expected to rise dramatically and also coal prices to a lesser extent.

The implementation of a carbon charge in 2007 as part of the Government's Climate Change policies will have a similar effect. The carbon charge has a cap of \$25/t carbon dioxide (CO_2) equivalent. This carbon charge will apply to gas and coal and to geothermal heat but not biomass based fuels.

The kind of price increases that New Zealand households and businesses might face from an emissions charge, based on the likely international price range for a tonne of carbon are shown table A3.1.

Table A3.1. Estimated Price Increases Resulting from Possible Emissions Charges

Estimated Price Increases				
Commodity	**\$10/t CO_2**		**\$25/t CO_2**	
	Residential	Industrial	Residential	Industrial
Petrol	3 cents/litre (2%)		6 cents/litre (6%)	
Diesel	3 cents/litre (5%)		7 cents/litre (12%)	
Electricity	4%	6%	9%	16%
Gas	3%	9%	8%	24%
Coal	8%	17%	19%	44%

The estimated price increase effect on coal prices is shown in figure A3.3

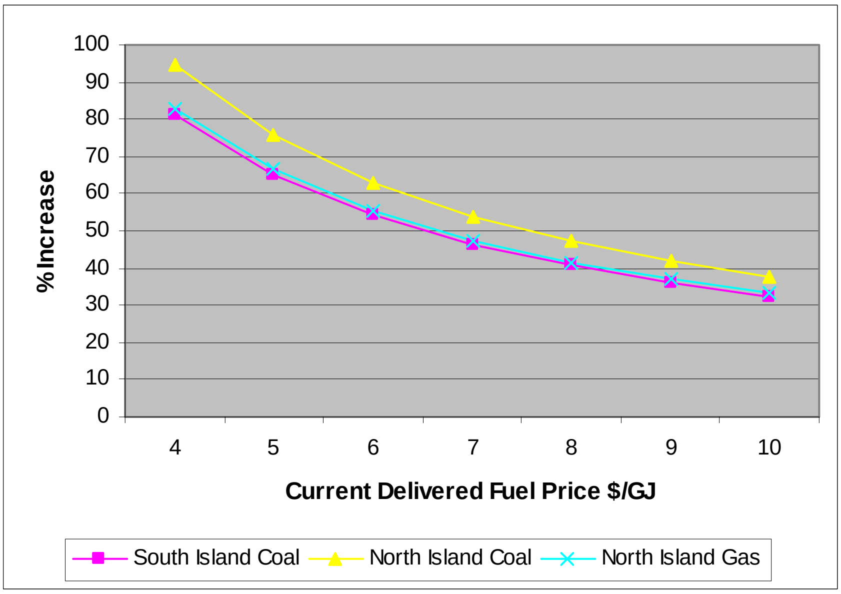


Figure A3.3

These are significant cost increases for those companies using coal or gas for heating.

Additional heating costs arising from possible carbon charge increases are shown in Table A3.2. These costs will vary according to individual circumstances but give an indication of the magnitude of the increase.

	Additional Heating Costs * $/GJ
Individual Cost Increases	**South Island Coal**
Increased gas and coal cost only	1.43
$25/t CO_2 charge only	3.09
$10/t CO_2 charge only	1.24
Combined Increased costs $/GJ	
Gas $2/GJ plus $25/t CO_2	4.52
Gas $2/GJ plus $10/t CO_2	2.67

*These heating costs are based on boiler efficiencies of 70% for coal

Table A3.2 Additional Heating Costs *

The combined effects of increased gas and coal price and a carbon charge on heating costs is shown in figure A3.4. The possible electricity generation costs post 2007 are shown in figure A3.5.

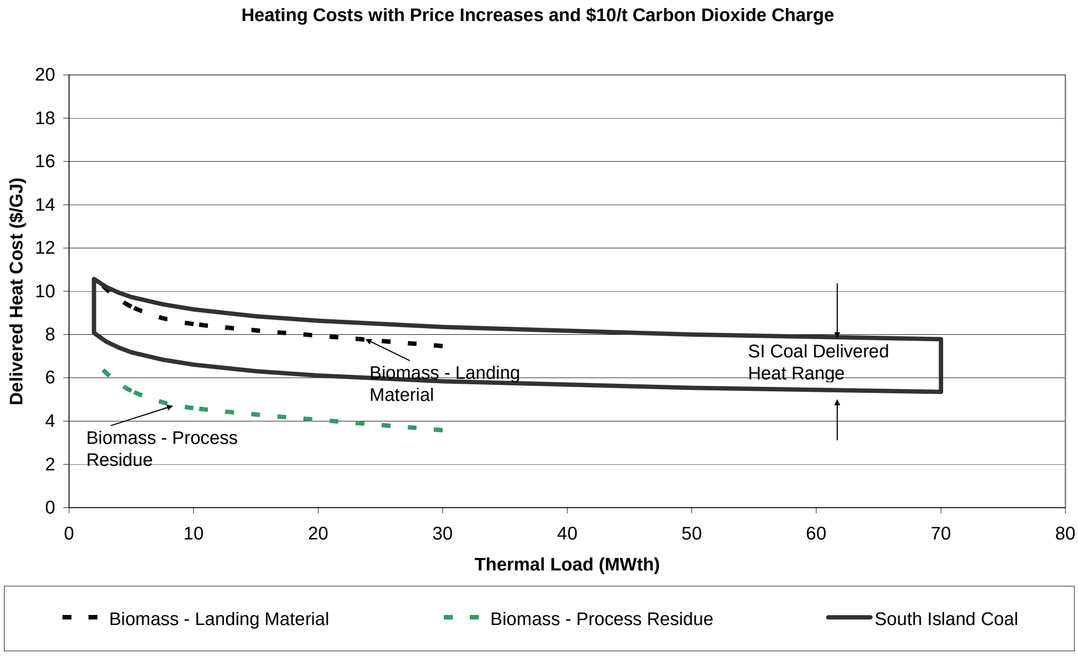


Table A3.4 Heating costs with gas price increase and carbon charge

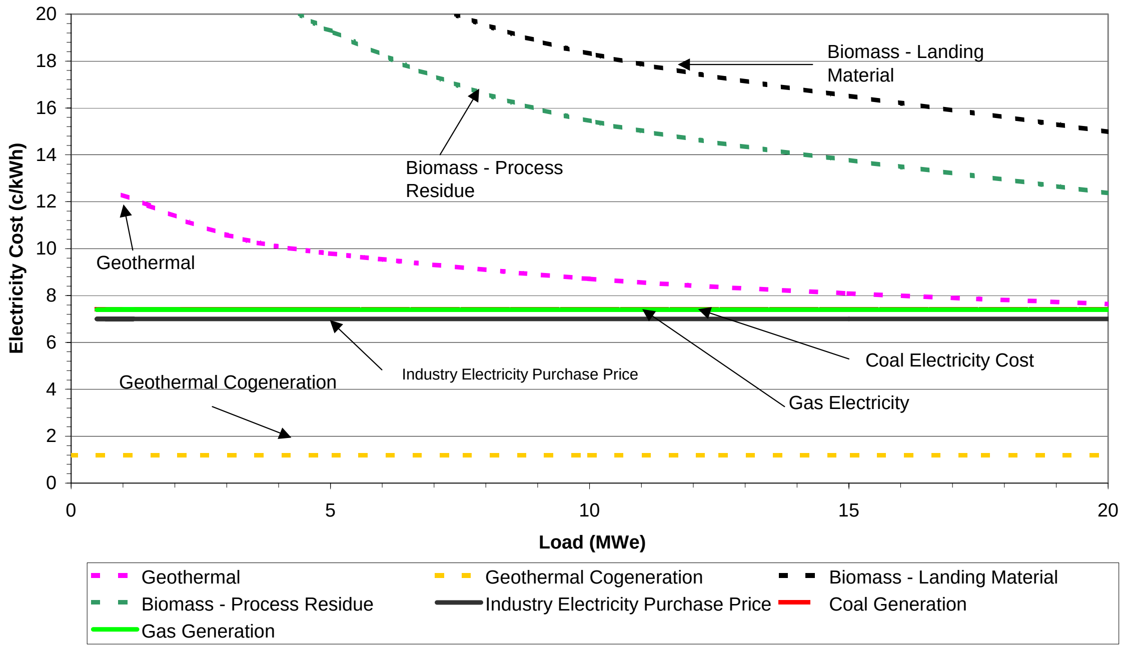


Figure A3.5 Electricity Generation Costs Post 2007

A3.5 Transmission.

Throughout the country there are a number of regions where there are electricity transmission constraints and thus even higher electricity prices will occur in these regions. While there are alternative energy resources in some of these regions there are a number of issues that indicate that transfer of energy source will not occur in the short/medium term.

The regional costs of energy are affected greatly by national grid transmission constraints. Transpower's approach to overcoming these constraints is not conducive to their resolution. Until Transpower's Statement of Corporate Intent is changed the costs imposed will remain. The constraints are getting worse and it is expected that they will have to be addressed within the next few years. These constraints are most significant in the northern half of the North Island but central South Island constraints have an effect on Southland.

Transpower consider that Financial Transmission Rights (FTR) may address many of these constraint issues. However the emphasis in any solution should be on minimising physical constraints.

It is important that the region involve itself in the development of transmission policy in order to get the problems addressed.

A3.6 Investment Response

The energy sector has plans for or is constructing a number of new electricity generation facilities that will assist meet electricity demand. These are principally based on gas, hydro or wind energy. Some of the projects are consented while others are just entering that phase.

For large energy projects obtaining consents through the Resource Management Act (RMA) process takes a long time, particularly if the consents are appealed. This can take from four to ten years so will be a significant constraint to the development of responses to possible shortfalls in energy supply.

It is noticeable in figure A3.2 that future new electricity supply is projected on a national basis to come from coal and renewable energy, both of which Southland has in abundance. These will each create significant investment issues unless managed well.

A3.7 Market Responses

There are a number of initiatives that the community can take to manage energy costs. Government has established a number of programmes under the National Energy Efficiency and Conservation Strategy to assist. Achievement of a 20% improvement in energy efficiency from the Strategy would reduce energy demand potentially by the equivalent of a fifth of a Kupe sized gas field.

Clusters of energy users can achieve a balancing of peak loads, economies of scale for fuel management, and make cogeneration economic.

Appendix 4

Current Energy Costs

A4.1 Electricity Market Pricing

Overview of electricity market

The wholesale market for electricity is administered by M-co. The main participants are the generator/retailers who trade at the 244 nodes across the transmission grid. Transpower performs the functions of Grid Owner, Grid Operator, Scheduler and Dispatcher for the wholesale market.

Spot Prices

In the electricity wholesale market, electricity is regarded as a different commodity in each half hour period of the day. Every day generators provide the market with a supply curve for each of the 48 half hour periods in the day for the following day and similarly electricity buyers provide a demand curve. The supply and demand curves received from each participant are aggregated and a single ex ante price is determined for each period. However, the final spot price is not determined until after the completion of the period. The price of electricity therefore varies according to the time of day, the day of the week and the time of year.

Nodal Prices

Wholesale electricity prices are set throughout the country by reference to nodal prices. These are the prices set at the Transpower grid exit points referenced to the South Island price at Benmore. The difference in nodal price reflects the system losses accumulating to that supply point. Retail electricity suppliers pay for electricity received at these points. The retail suppliers then add their margin and sell to customers according to either a fixed price (monthly or half hourly), or a floating price and referenced to the half hourly spot price at the nearest grid exit point.

The wholesale electricity prices for the region are established for the grid exit points at Invercargill, Gore, Edendale, and Brydone. At each of these the half hourly nodal prices are very close with those in Invercargill being the lowest. From data taken during 7 June to 6 July 2003 the average differences in nodal price at Gore, Edendale, and Brydone with that of Invercargill are 0.25, 0.21 and 0.22 c/kWh respectively. As this is not a long period of sampling this may not hold for the long term. These communities in these areas represent different types of loads. Invercargill a small city, Gore a rural town, Edendale a rural community (it is assumed that the dairy factory is using its lowest amount of electricity over this period) and Brydone a large industrial facility. The price at Invercargill will also reflect the influence of the smelter at Tiwai.

Retail Prices

Electricity Invercargill and The Power Company are lines companies and Contact Energy and Meridian are the major electricity retailers in Southland.

A4.2 Electricity Charges - Medium Sized Residential / Commercial Users

Retail electricity prices for residential customers are shown in table A4.1.

Southland													
Line Business	**Approx. No. of Residential Consumers by Line Business**	**15-Nov-99**		**15-Feb-03**		**15-May-03**		**% Change**		**% Change**		**Total Increased Cost (+) or Annual Saving (-)**	
								15-Feb-03 to 15-May-03		**15-Nov-99 to 15-May-03**		**15-Nov-99 to 15-May-03**	
Retailer		**Line**	**Retail**	**Line**	**Retail**	**Line**	**Retail**	**Line**	**Retail**	**Line**	**Retail**	**Line**	**Retail**
The Power Company	25,605	**6.26**		**6.54**		**6.54**		**0%**		**4%**		**$22**	
Contact Energy			13.76		15.57		15.57		0%		13%		$145
Meridian Energy			13.53		14.46		14.46		0%		7%		$74
Electricity Invercargill	14,282	**6.11**		**6.54**		**6.54**		**0%**		**7%**		**$34**	
Contact Energy			12.92		15.23		15.23		0%		18%		$185
Meridian Energy			12.56		12.83		13.87		8%		10%		$105

Source MED

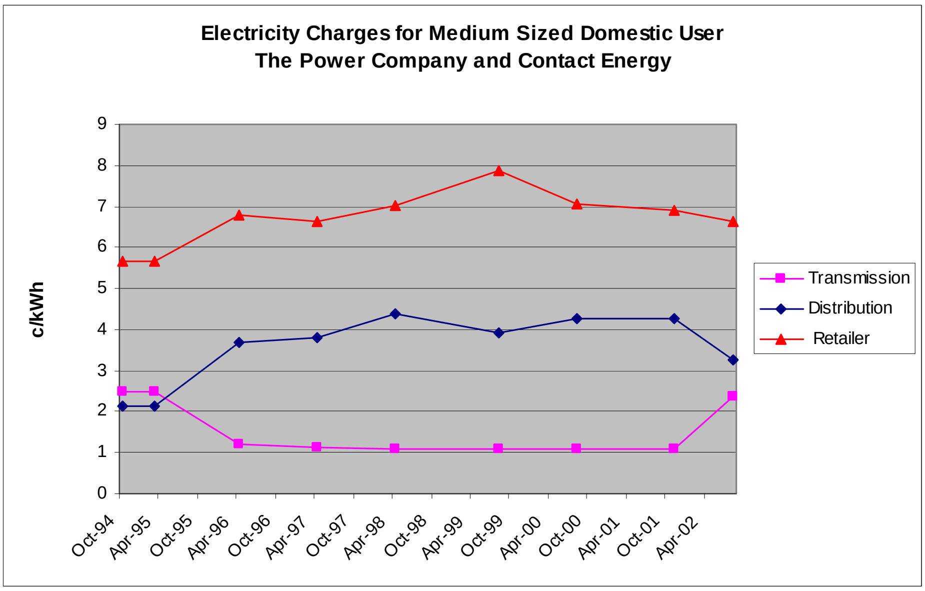
Table A 4.1

The characteristic of each consumer type used in the following graphs are set out in table A4.2

Consumer		**Consumption** (kWh per Month)
Domestic	Small	500
	Medium	1000
	Large	1500
Commercial	Small	500
	Medium	1500
	Large	3500

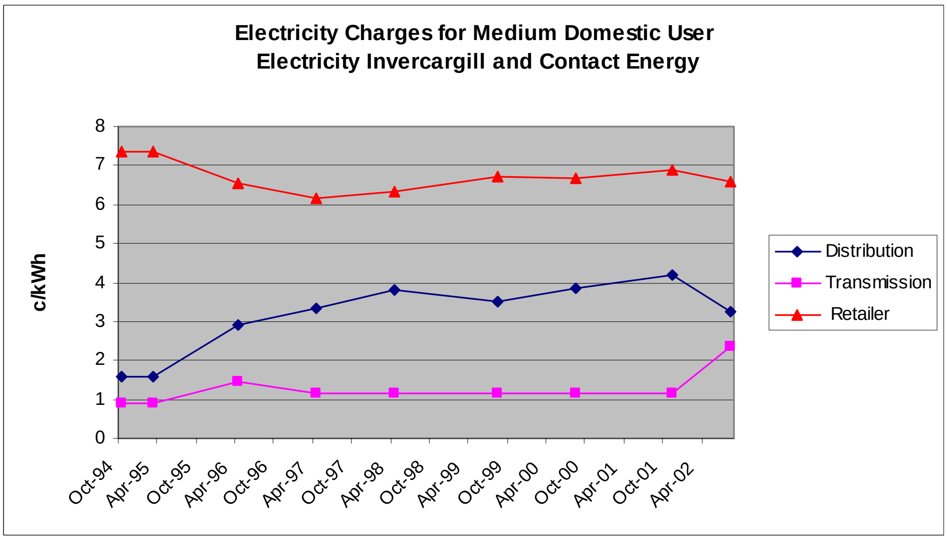
Table A4.2

The historic trends for electricity transmission, distribution and retailer charges for medium sized domestic user and a medium sized commercial user are shown in the following graphs. It should be noted that the domestic charges include GST whereas the commercial ones do not.



Based on MED Data

Figure A4.1



Based on MED Data

Figure A4.2

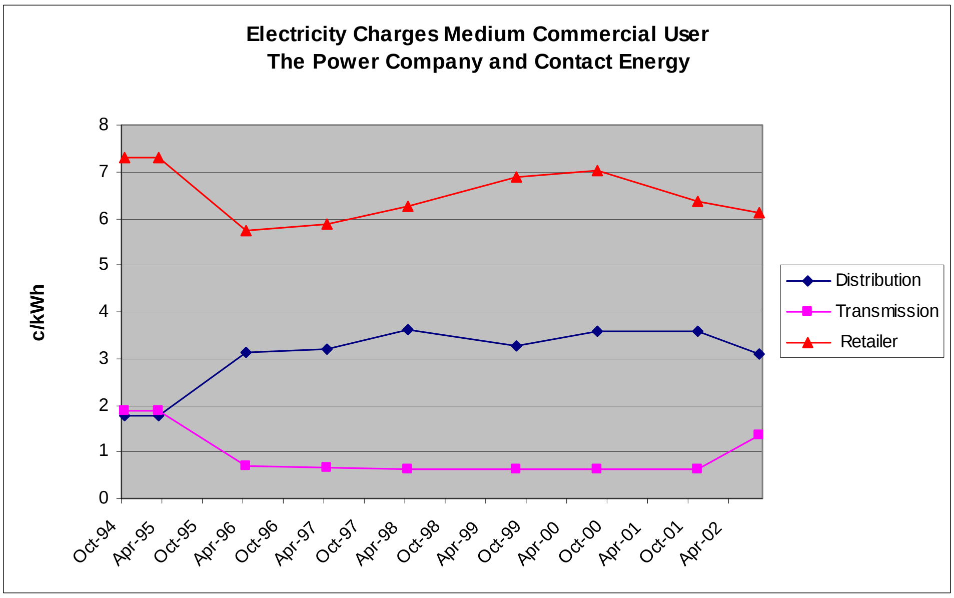


Figure A4.3

Based on MED Data

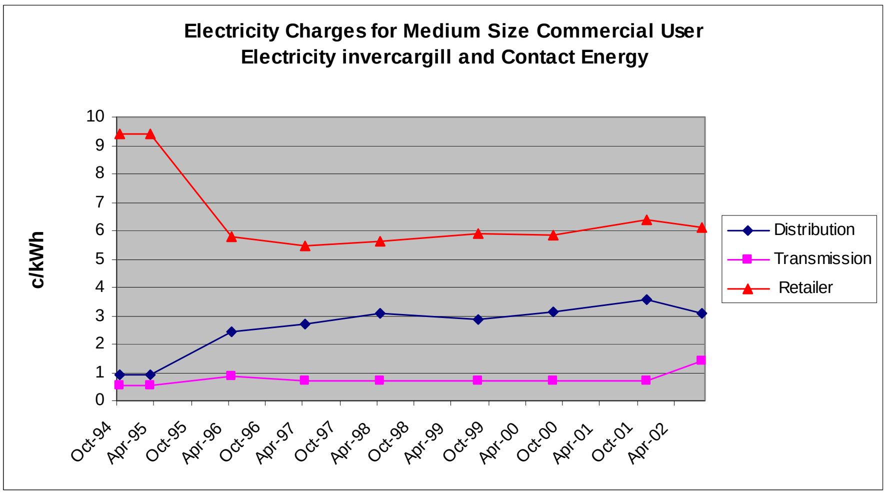


Figure A4.4 Based on MED Data

A4.3 Electricity Distribution Costs

The lines charges for different sized users is shown in figures A4.5 –A4.8

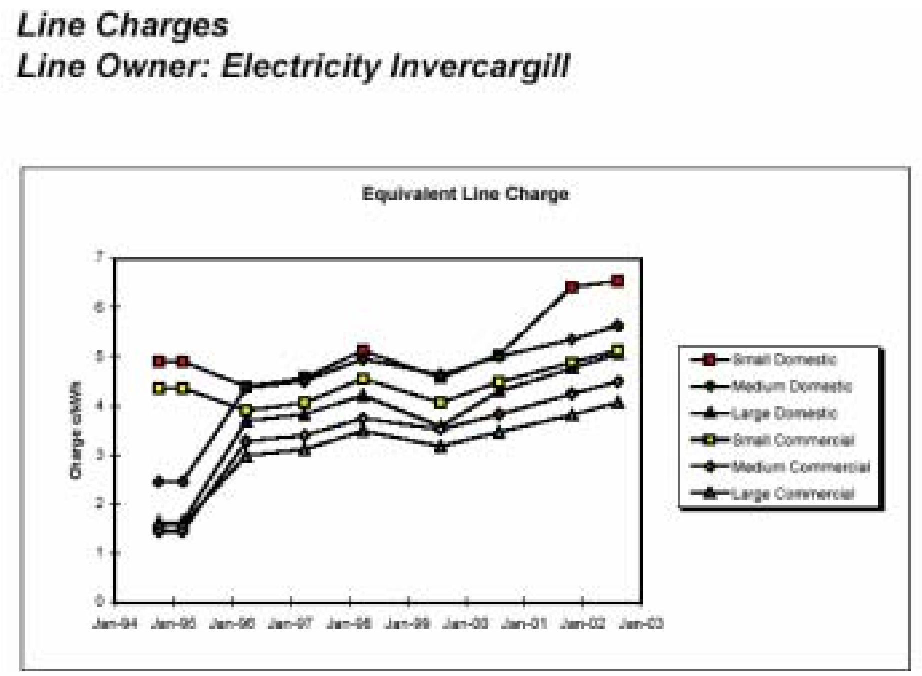


Figure A4.5

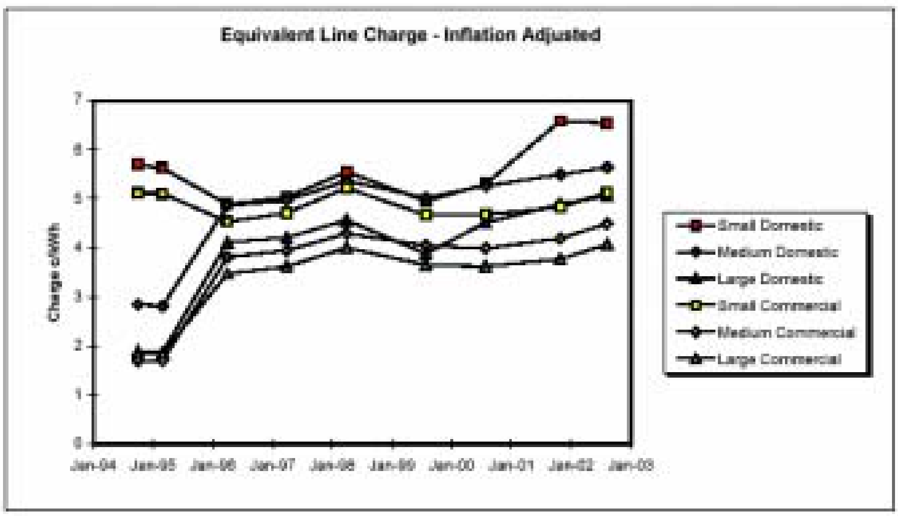


Figure A4.6

Line Charges
Line Owner: The Power Company

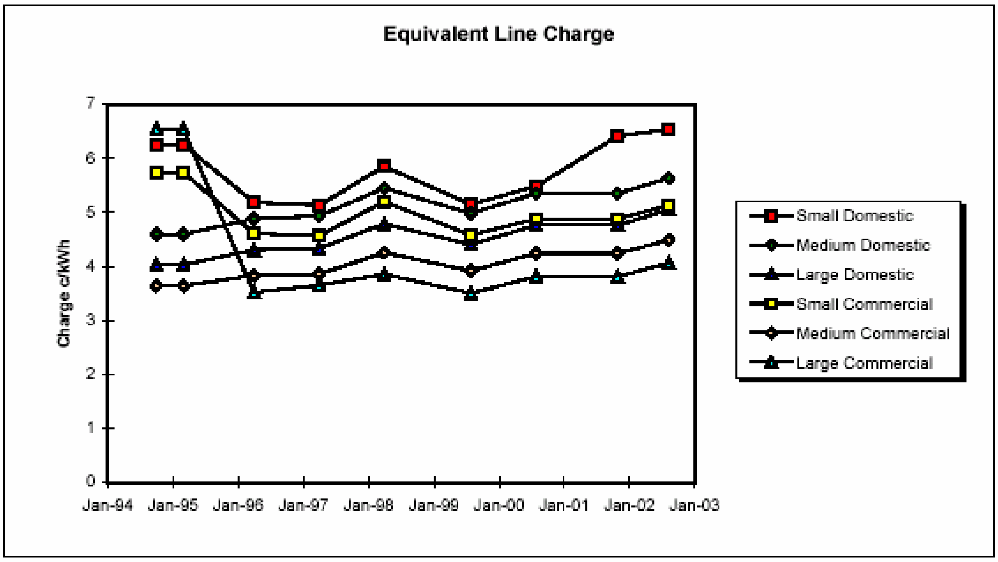
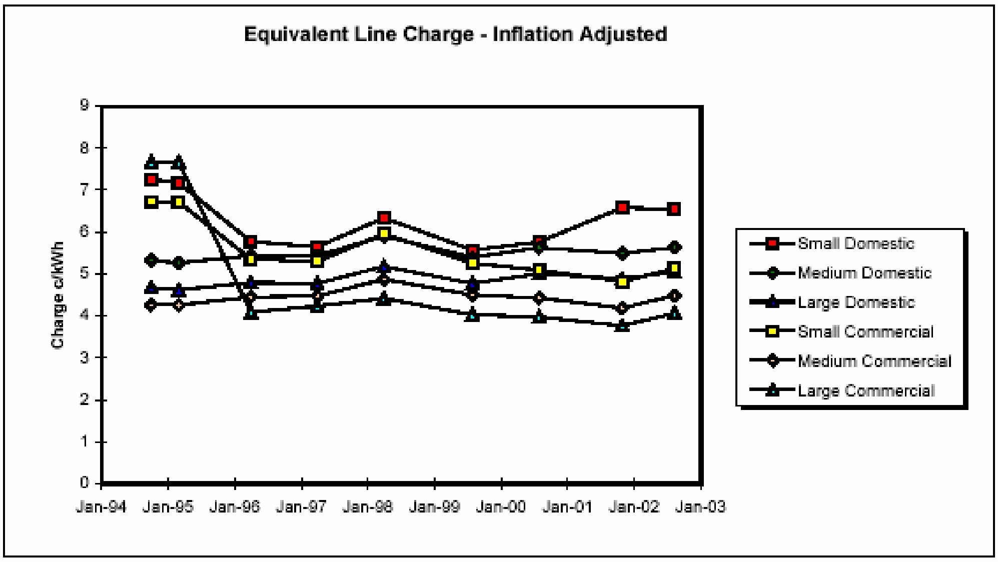


Figure A4.7



In the last year both lines companies charged the same for domestic customers.

A4.4 Retail Electricity Costs

The retail energy costs from the incumbent electricity retailer, Contact Energy, are shown in figures A4.9 – A4.12.

Incumbent Retailer: Contact Energy
Line Owner: Electricity Invercargill

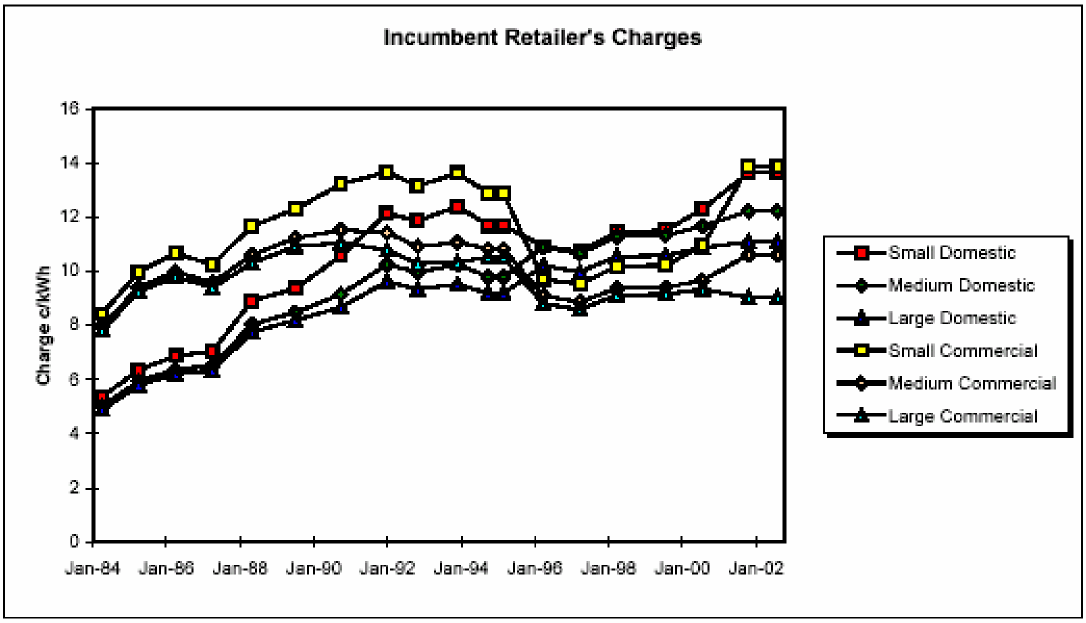


Figure A4.9

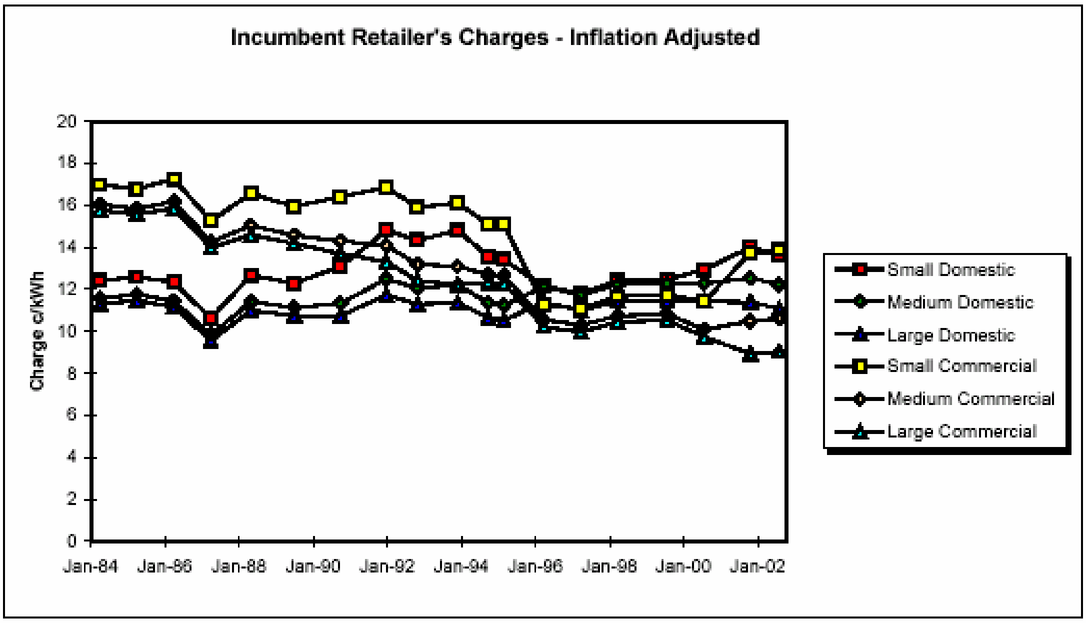


Figure A4.10

Incumbent Retailer: Contact Energy
Line Owner: The Power Company

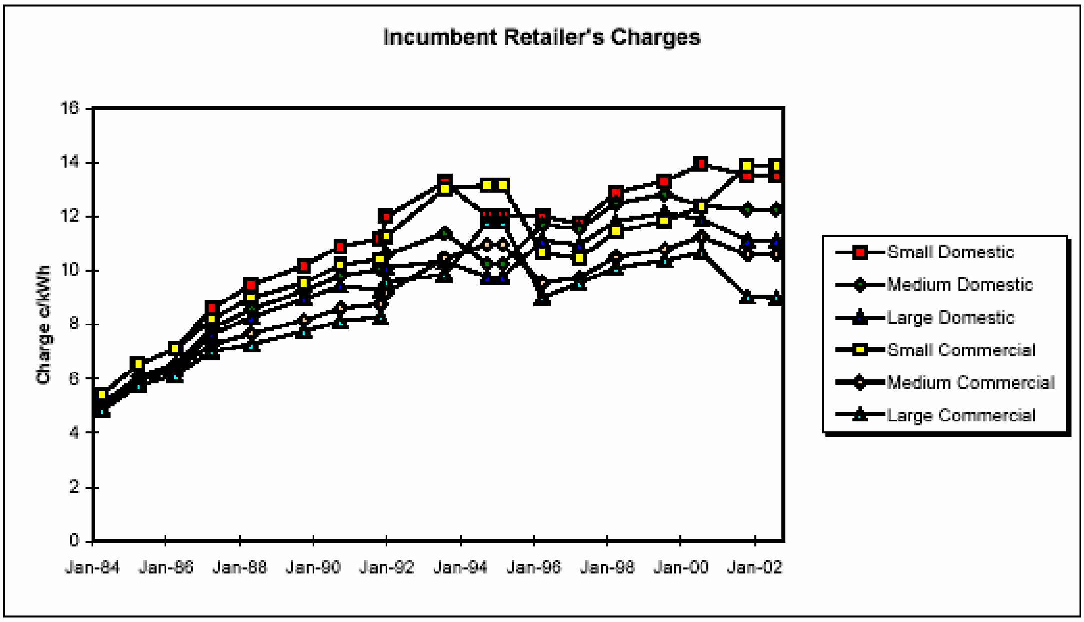
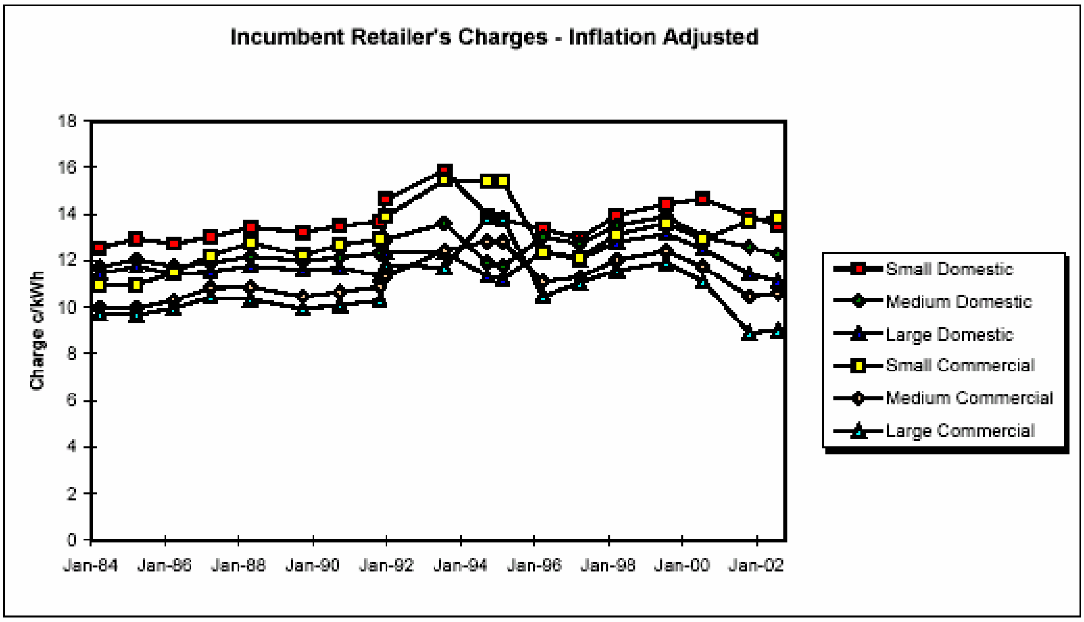


Figure A4.11



Source: Ministry of Economic Development

Figure A4.12

A4.5 Reserve Generation

The Government has committed to installing Reserve Generation to provide an electricity price cap in the event of further dry hydro years. The Reserve Generation can be in any form of generation, any fuel type and can be just fuel itself. The proposed Electricity Commission will contract to plant or fuel owners for the Reserve Generation to be available.

In the first instance the Government has signed a contract with Contact Energy for 150MW of diesel fuelled gas turbine generation to be located at Whirinaki in the North Island. The Government is discussing with other parties additional or alternative locations for the Reserve Generation. The first plant is to be installed by the 2004 winter.

Installation of a similar 150MW of diesel generation in Southland would be very beneficial to ensuring that Southland electricity demand could be met in a dry year and prices would be capped.

In a dry year it is the constraint of electricity flow from the north that constrains supply. If 150 MW of Reserve Generation was available this would limit the necessity to try and get electricity from the north because it would be generated where demand existed.

Reserve Generation will be expensive at around 15-20c/kWh. For the region it will only be of benefit during dry years. For a longer term supply solution other options are more durable and cost effective. The problem is that they can not be installed by the 2004 winter constraints could next occur.

Appendix 5

Wind Energy

Wind is caused by atmospheric temperature and pressure gradients which because of its position with regard to south westerly winds makes Southland attractive, although not the most attractive, area in NZ for wind farm development. Energy produced by a wind turbine depends mostly on the average wind speed, the shape of the annual wind speed distribution curve, combined with the turbine height above ground.

Wind turbine generators (wind turbines) can produce alternating current (AC) or direct current (DC) electricity as required by the application, e.g. DC for small remote electricity generation or water pumping systems, or AC for electricity grid connections. Windmills are also used for direct pumping of water.

Wind turbines can be located on land, or at sea with towers fixed to the seabed. Normally at sea the wind is stronger, more consistent, and less turbulent and offshore installations are occurring extensively throughout Europe. However, capital costs for offshore installations are greater, even more so in Southland as the seabed near the coast is likely to be more inhospitable than for European sites.

A5.1 Resource Information

Information on the Southland wind energy resource is constrained by the lack of publicly available data. The wind maps available to the public were prepared from data collected in the 1980's and advice from wind farm developers is that they greatly under estimate the resource. The monitoring being undertaken by wind farm developers is not publicly available.

Because of the extreme importance of having reliable data for assessment of wind energy the wind maps in figures A5.1-A5.3 were commissioned from the National Institute of Water and Atmosphere (NIWA). These maps indicate that the high wind speed areas are along the south coast, in some of the valleys of western Southland, and on some of the higher hill areas of inland Southland. Stewart Island is a low wind speed area.

In order to overcome a major barrier to the uptake of wind energy it is recommended that reliable wind data at different elevations be obtained in order to identify the characteristics of the resource at potential turbine hub heights. This information should be made publicly available to assist those interested in wind energy to undertake evaluations of their specific opportunities.

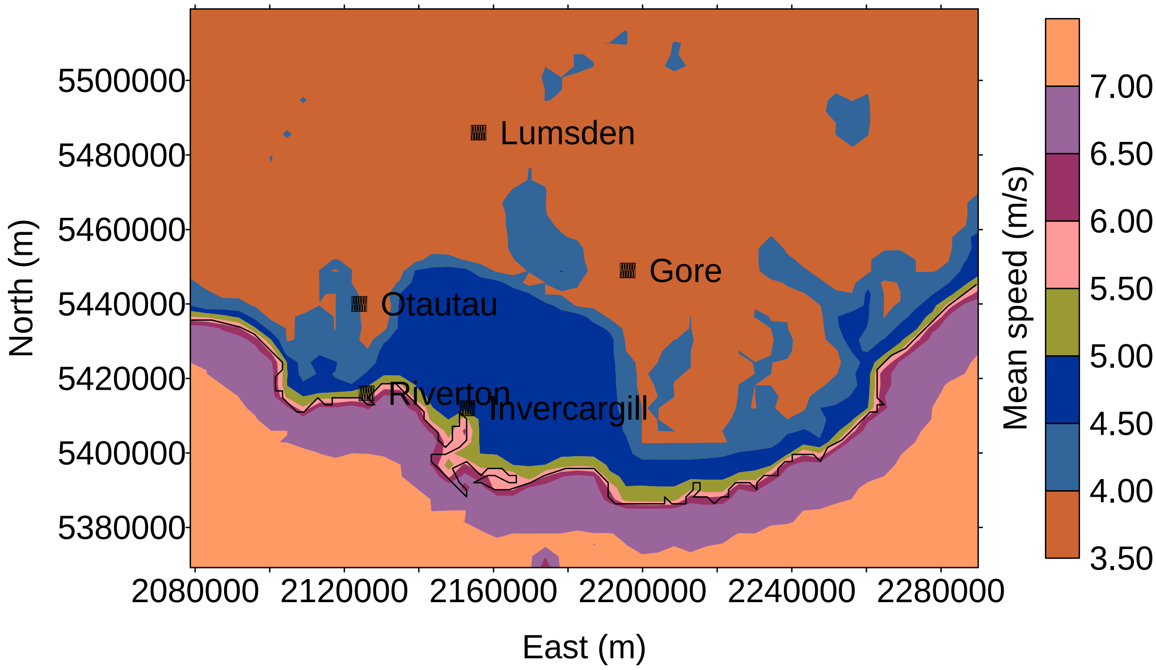


Figure A5.1 Wind Resource Map at 10m elevation above ground level

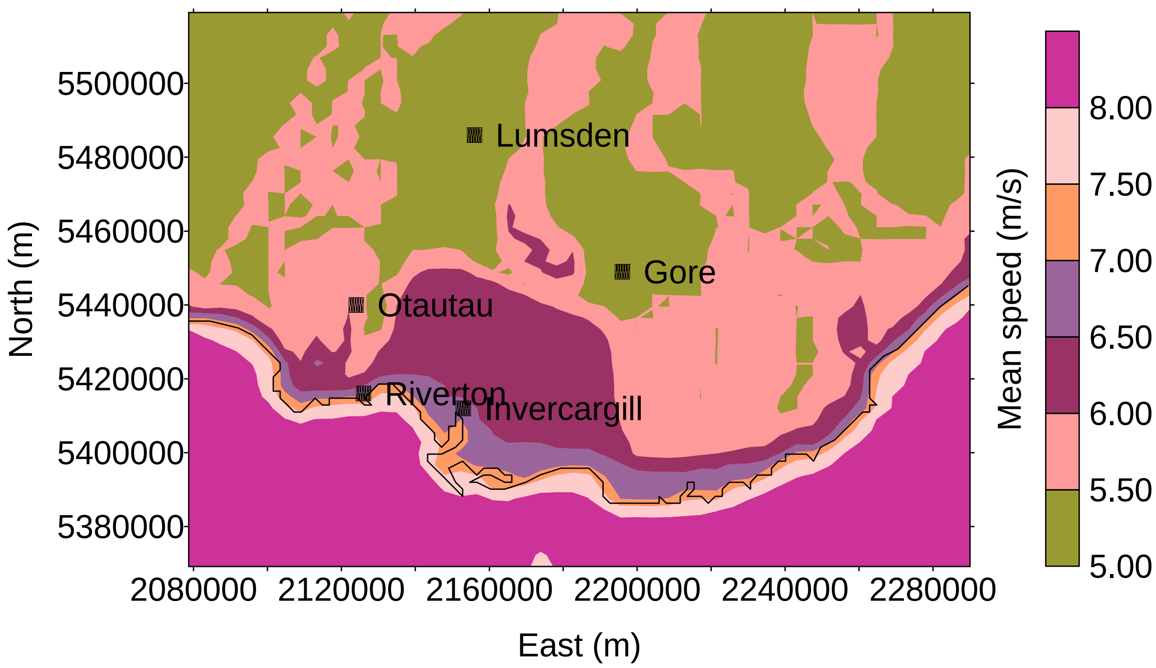


Figure A5.2 Wind Resource Map at 40m elevation above ground level

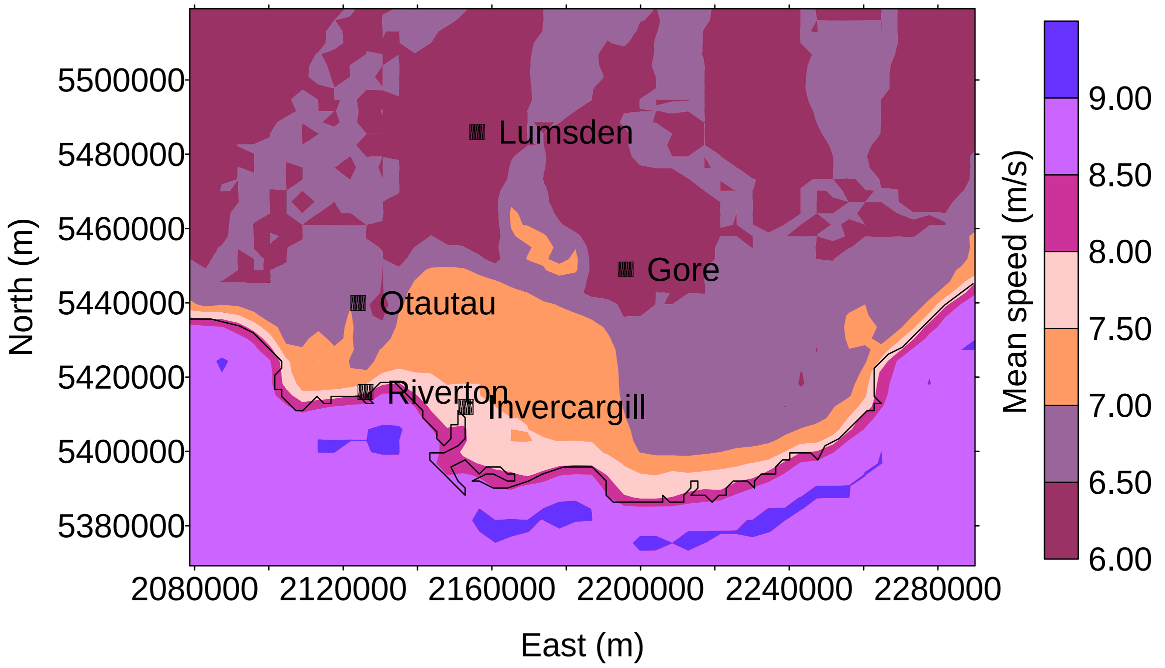


Figure A5.3 Wind Resource Map at 80m elevation above ground level

A5.2 Technology

The main elements of a wind turbine generator are the turbine rotor system, the drive train and generator, support structure, and ancillary works. This consists of blades attached to a hub with blade control mechanisms, if any. Two configurations are common:

(1) The horizontal axis wind turbine usually with two or three blades, with the horizontal axis in line with the wind.

(2) The vertical axis wind turbine where the blades move around a vertical line, perpendicular to the wind direction. Machines of this type are no longer produced in significant quantities worldwide.

In the past decade, the configuration of wind turbines has almost exclusively standardised on three bladed horizontal axis machines with upwind rotors. However, it is not possible to rule out advances in technologies that could see some alternatives, such as vertical axis or two bladed wind turbines, being installed in the future. Other technology advances such as the gearbox being developed by Windflow in Christchurch are also occuring.

In a conventional three bladed wind turbine the blades are rigidly mounted to a horizontal main shaft. The rotor is coupled to a generator either through a speed-up gearbox (e.g. Wellington Wind Turbine and Tararua Wind Farm), or directly for some variable speed turbines (e.g. Hau Nui). The average sized wind turbine installed has increased over time so that up to 2.5 MW machines are now being installed in Europe. However the most common turbine size range is still in the 600 kW (0.6 MW) to 1.8 MW size range, with 2-3 MW and larger machines either under development or just entering production. The Tararua Wind Farm has 660 kW sized turbines, while Meridian Energy is proposing to use 1.5 -1.75 MW turbines for its wind farm in the same area..

A typical grid connected machine stands 40-100 metres tall with rotor diameter of 40-70m. Towers are normally tubular steel or concrete, or steel lattice. The bottom of tubular towers can accommodate electrical control and switchgear equipment. Smaller dairy farm scale machines can be on 10-30m towers.

Table A5.1 gives an indication of dimensions related to generation capacity.

Rated Power (kW)	Rotor Diameter (m)		Hub Height (m)	
	General	**Typical for NZ**	**General**	**Typical for NZ**
600-750	40-50	45	40-50	45
800-1,500	50-65	55	50-65	55
1,500-2,000	65-80	70	65-80	70

Table A5.1 Size/Generation Relationships of Modern Turbines

The rotor hub is connected to an electrical generator through a drive train while most drive trains include a gearbox. However, direct drive generators are also used.

Often, in low wind speed situations such as parts of Europe, larger rotors and/or taller towers of Class 2 machines are used to increase the energy yield of the turbines[2]. A 65 metre high tower might be used on a 600 kW turbine or a 1.8 MW turbine might have a 100 metre tower. It would appear that such a situation may be desirable in Southland to improve the economics but it is uncertain whether they could withstand peak winds.

The wind turbine converts the available energy in the wind into electricity. It is designed to extract as much energy as possible out of the wind, up to the so-called rated wind speed. At the rated wind speed (for most large scale turbines around 12-16 m/s) it produces its nominal or rated power. Between the rated wind speed and the cutout wind speed (for most large scale turbines between 25-35 m/s), the wind turbine control system or blade design limits the output power to (on average) the rated power. In this operating window, the wind turbine “spills” excess energy.

Wind power technology is a mature technology and many commercial plants are available. As with most mechanical plant, operating and maintenance costs tend to increase through the life of a wind turbine. Overall life is unclear. It may be 15 to 25 years with possibly a major overhaul after 10 years.

Unlike hydro power plants, the inflow of energy in a wind turbine is turbulent and chaotic, unsteady, varies with elevation (wind shear) and changes direction continuously. Modern wind turbines have to deal with this time and space variable energy inflow which together with the 100 million plus rotor revolutions, makes the fatigue life of a wind turbine an important issue. Fatigue now constituting a large amount of wind turbine R&D effort.

There are a number of small scale turbines suitable for pumping or electricity generation on dairy farms available, but the small number being installed does not provide economies of scale for supply.

With the first commercial wind farms having been installed in the North Island, New Zealand is now gaining real experience of different machines. The timing of purchases, with large wind farms being developed in Australia, may assist reduce costs.

[2] Wind speed generally increases with height above land.

A5.3 Applications

Large Scale Wind Farms

Wind turbines are usually arranged in wind farms - multiple wind turbines forming a single managed unit in a generally contiguous area. The modular nature of wind turbines means wind farm capacities can be variable to suit land availability, load demand and other factors. Generally wind farms have a capacity of up to several MW. While not precluding the use of larger sized turbines, the medium size wind turbines (600 kW to 2 MW) are probably best suited to New Zealand conditions, due to crane and transportation constraints.

Only high wind speed sites (with hub height wind speeds of approximately 9-10 m/s) will initially be economically viable for grid connected turbines. Turbines more suited to lower wind speeds may be applicable away from the coast where the wind speed is lower but this requires further investigation.

It is likely that wind turbines installed in Southland will have rotor diameters of no less than 40 metres and tower heights no less than 40 metres[3].

It is often estimated that more than 30% of New Zealand's present day electrical energy needs could be met by wind power before reaching the integration limit. In today's terms and on a pro rata basis this would mean that about 500 MW can be installed in Southland. These integration limits apply in part because, of all the wind turbines presently installed, the majority use induction generators to produce electricity. The utilisation of synchronous generators and power electronics will increase the possible grid penetration. However it is unlikely that such a large amount of installed capacity will be developed in the near future. There are also requirements for the operation of Lake Manapouri and constraints on electricity flows north through the Transpower grid that are likely to limit the maximum capacity to around 150MW unless the grid constraints were lifted. This assumes no other generation from other energy form is installed. The exact limits can only be established by modelling the electricity load flows.

Weak Grid

The adaptability of wind turbines to weak grid situations is being improved by the increased use of power electronics which control the import and export of reactive power. The wind turbines at Hau Nui, Wairarapa are an example of this. Other grid characteristics of turbines are also improving, with emphasis on soft start technologies, power factor correction, fault ride through, and flicker control. These features are somewhat counterbalanced by the increasing trend to larger turbines which, despite having improved power quality features, may not be able to be easily accommodated at grid points where the installation of a smaller turbine may have been possible.

A scattered distribution of medium sized wind turbines at industrial locations throughout Southland could assist support for the distribution network. Each would however be on a case by case application.

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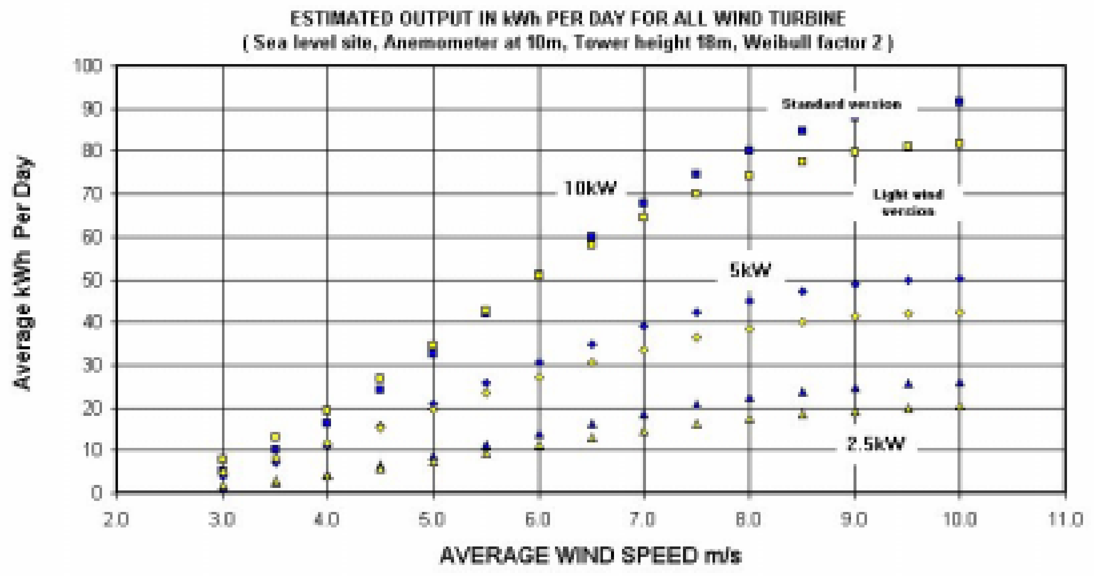
[3] The 48 wind turbines installed at the Tararua Wind Farm have a 45 m hub height and 47 m rotor diameter.

Smaller Wind Turbines for Dairy Farm Applications

There is a market for wind turbines to supply electricity in rural locations. Examples include the supply of electricity to remote locations such as houses, farms, lighthouses and telecommunications facilities. Unlike the larger grid connected wind turbines that generate electricity controlled with respect to voltage and frequency, small wind turbines for remote applications are usually optimised for battery charging. Inverters to generate AC electricity can in turn use this battery power.

Wind turbines for remote rural applications vary in capacity from a few hundred watts to about 10 kW. The consequent rotor diameters vary from 1-7 metres. Tower heights for these wind turbines typically range in height from 10 to 30 metres. The energy output increases significantly according to the size of the machine.



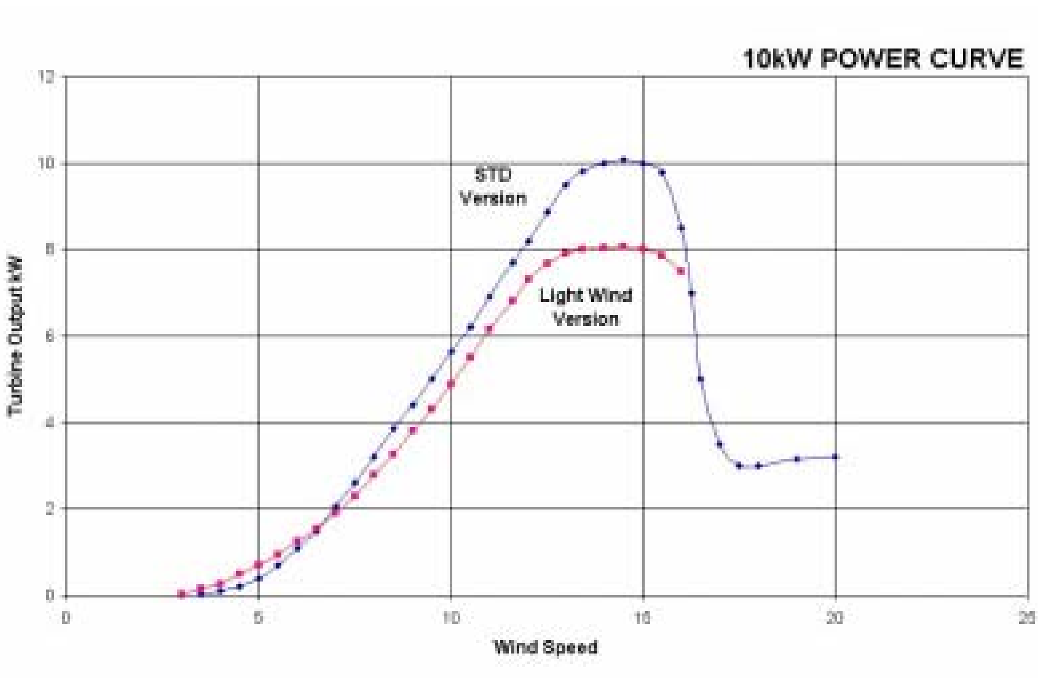


Figure A5.4

A turbine used to supply a single remote household would typically be rated at about 1 kW. Such a wind turbine may often not be placed in a resource-optimised location as proximity to the user is the most important factor. Also some of the energy from the wind turbine will not be able to be accepted by the system, e.g. if the batteries are already full. These two factors mean that the maximum effective capacity factor for such a turbine is likely to be approximately 30% or less. This compares with capacity factors of up to 50 percent for wind farm installations in optimum sites. In order to generate the same amount of electricity as the 32 MW Tararua Wind Farm, it is estimated that the installation of 50,000 small 1kW turbines would be required.

Hence the installation of small remote area wind turbines is unlikely to make a significant contribution to Southland’s energy supply. Despite this, they are likely to be of increasing importance in providing energy services to areas where alternative energy supplies are uneconomic.

Extending Hydro Storage

The hydro domination of Southland's supply means the integration of wind power is unlikely to be an issue if the hydro supply is used to firm the wind energy. There is a synergy between wind and hydropower. The lakes behind hydro dams could be seen as providing storage for wind energy (when wind energy is available hydro storage is increased). Wind energy therefore has some potential to increase Southland’s reliability of supply (through a diversity of energy sources).

A5.4 Barriers

Despite earlier concerns that the characteristics of New Zealand’s wind resource (such as extreme gusts) may have meant that there were limitations on the use of internationally developed wind generation technology in New Zealand, that has not proved to be the case for the majority of designs available.

In practice, the limitations on the use of wind energy generating technology in the New Zealand context are more likely to be related to aspects not connected to the technology or the resource itself. Aspects include access to areas or electricity distribution lines, construction capacity (including availability of lifting equipment), grid characteristics, turbine and construction costs, and the ability to obtain resource consents.

The key issue for wind generated electricity is that it is difficult to meet guaranteed supply contracts in terms of time and quantity of delivery at the same time as commanding a sale price that makes development economic. This is not an issue if it is supplied on a take it when it comes basis such as for injection into the wholesale market, or for embedding within an industrial site.

Wind power is not continuous so it cannot be relied upon solely unless there is an associated energy storage system (e.g. hydrogen production - fuel cell generation, diesel generation, or hydro storage lakes). It is well suited to work with other sources of electricity generation that can cover any wind shortfall, and can be integrated up to a limit within a national grid system.

Sub-second, second and minute-by-minute power fluctuations of a single wind turbine are a function of the variability of the wind speed as well as the technical characteristics of the wind turbine. The nature of wind power is such that, while single wind turbines have fluctuating power output, this variation decreases dramatically as increasing numbers of units are installed. Fluctuations in power output have also been reduced by technologies that introduce drive train compliance, such as variable speed.

Scheduling the power generation of other generating plants and forecasting of the wind resource easily accommodates the hourly and daily variations in wind speed. The same smoothing effect on the variable energy contribution but on a longer timeframe may occur if wind farms are installed at different geographical locations throughout Southland.

The forecasting of tomorrow's weather can still be fairly accurate although the forecasting wind speed bands will be described only as "strong winds" or "moderate winds". These can be translated to expected amounts of wind energy and thus the expected alternative generation can be adjusted accordingly.

It is expected that wind farms will be smaller than 30 MW, be spread around the region and built in stages. This spread will ensure that the existing electrical network can take this amount of electricity injection and take timely action to ramp up (or down) additional capacity as the wind farm outputs change.

In addition, a network/wind farm operator will be able to forecast a possible high wind speed shutdown probability, and forewarn network operators. High wind speed shutdown situations may not occur that often (depending on the site characteristics), but are the most problematic in regards to the power output variability because of the fast transition between full load to no load. In a wind farm situation, not all the turbines in one wind farm will shut down simultaneously due to high wind speeds, as different parts of a wind farm usually experience different wind characteristics.

The movement of weather systems influences daily wind speeds, however it is known that deterministic diurnal effects also play a role. On low lying or coastal land, it is observed that the wind speeds are sometimes significantly higher in the afternoon than at other times of day (this diurnal pattern phenomena is more marked at lower than higher altitudes). Diurnal wind patterns can be variable, but nonetheless system power planners can often use it to advantage. Site specific wind data can be used to determine these patterns.

A5.5 Environmental

The lack of experience by communities of consideration of the environmental effects for wind turbines and associated wind farms give rise to significant uncertainties to investors in the resource consent process

The ability to obtain acceptable resource consents for wind farms is regarded by some as a significant barrier to future development. Resource consents can take some time to obtain, with a reasonable lead time of two years or more if there are appeals.

There is a risk of not achieving acceptable resource consents, as wind farm projects are not a permitted activity in Southland and must be evaluated in terms of national, regional and local policies. They are also evaluated on the basis of effects (as defined in the RMA), as well as under the more general “sustainability” criteria in Part II of the RMA. In practice, the process of consultation and participation under the RMA involves a significant level of risk as to whether consents may be able to be obtained or not.

The introduction by the Government of an amendment to the RMA that requires consent authorities to take account of renewable energy when considering a consent application will assist Councils significantly.

Any adverse environmental effects from remote wind turbines are likely to be confined to the users themselves. Emission offsets from the generation of a unit of electricity generated by a remote wind turbine are likely to be higher than from a grid connected wind farm on a per kWh basis. This is because the energy generated displaces electricity that would have been generated by small relatively inefficient petrol or diesel engines

One of the significant costs of wind projects is that of public consultation and the provision of good documentary evidence of the potential visual and noise effects to surrounding landowners. In addition there are issues with the acceptability of evidence on noise and other effects. There is a need for either standard information that would set a baseline that all parties could rely on, or guidelines as have been prepared for emissions to air. Site specific information can then be addressed in terms of this baseline information.

The collecting of data on a potential wind farm can strike problems from the beginning when a resource consent is required for a wind measuring tower. It would assist in the collection of good wind data if the consent for a wind tower were a permitted use, provided specified conditions were met eg removal within a specified time frame.

A5.6 Economics

Coastal Sites

Wind speed dominates the economics of wind farms. In the example, a 6 MW, 4 turbine farm situated on the southern coast the cost of electricity is 8.5 c/kWh with an average wind speed of 8.5 m/s. If the average wind speed increases to 9.5 m/s the cost drops to 7.3 c/kWh, on the other hand if the wind speed drops to 7.5 m/s the costs rise to 10.5 c/kWh. The economic effects of a ± 1 m/s change in average wind speed are greater than variations in a ± 10% change in capex or ± 2% change in Weighted Average Cost of Capital (WACC). The magnitude of the effects are illustrated in figure A5.5. It is essential therefore to have good wind data measured at the expected hub height of the wind turbine.

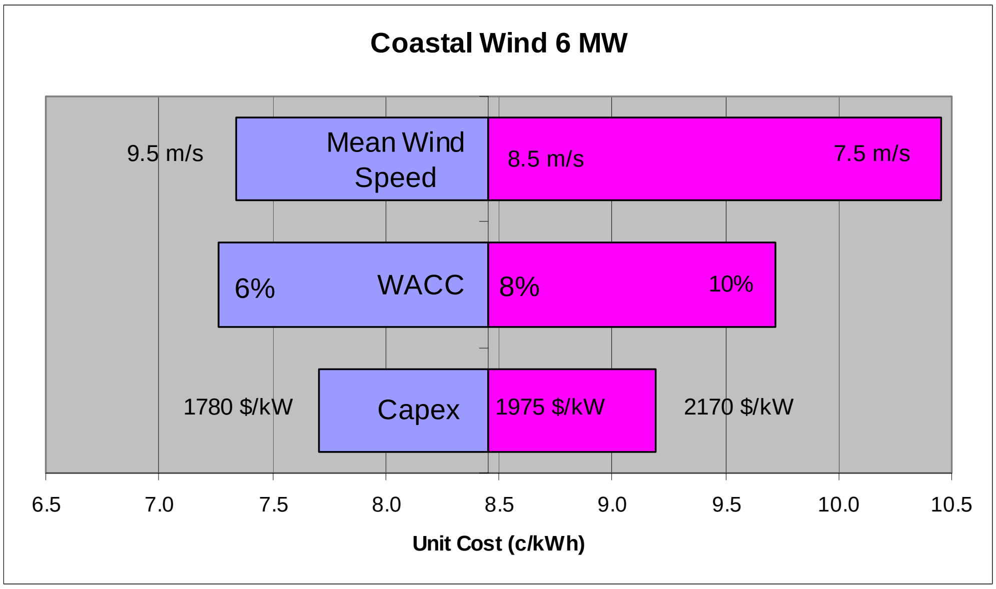


Figure A5.5

The variation in electricity cost with wind speed for a 4 turbine 6 MW farm is shown in figure A5.6

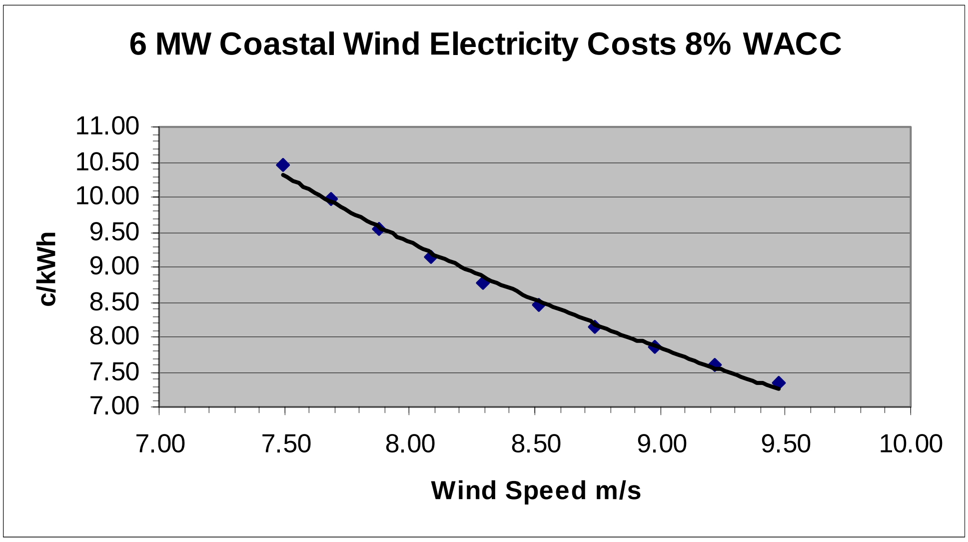


Figure A5.6

A larger wind farm of 30MW with some economies of scale would produce electricity for 8.0 c/kWh, a reduction of 0.5 c/kWh from that of the smaller 6MW farm. The tornado diagram for this farm is shown in figure A5.7.

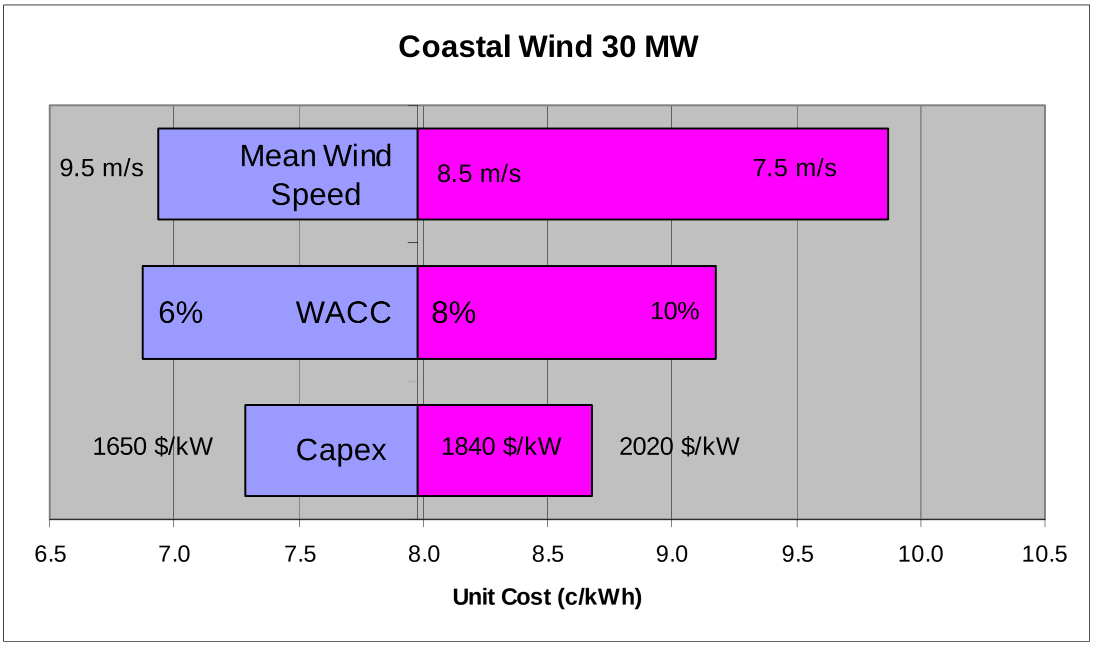


Figure A5.7

Inland Sites

Inland wind speeds are generally lower and therefore the costs of electricity generation are higher. This is illustrated by the electricity cost of 15.6 c/kWh from a single 600kW turbine with an average wind speed of 7 m/s. (For a smaller 225 kW turbine the electricity cost rises to 21.1 c/kWh at the same wind speed). Again wind speed is the determining factor in the generation economics as shown in figure A5.8

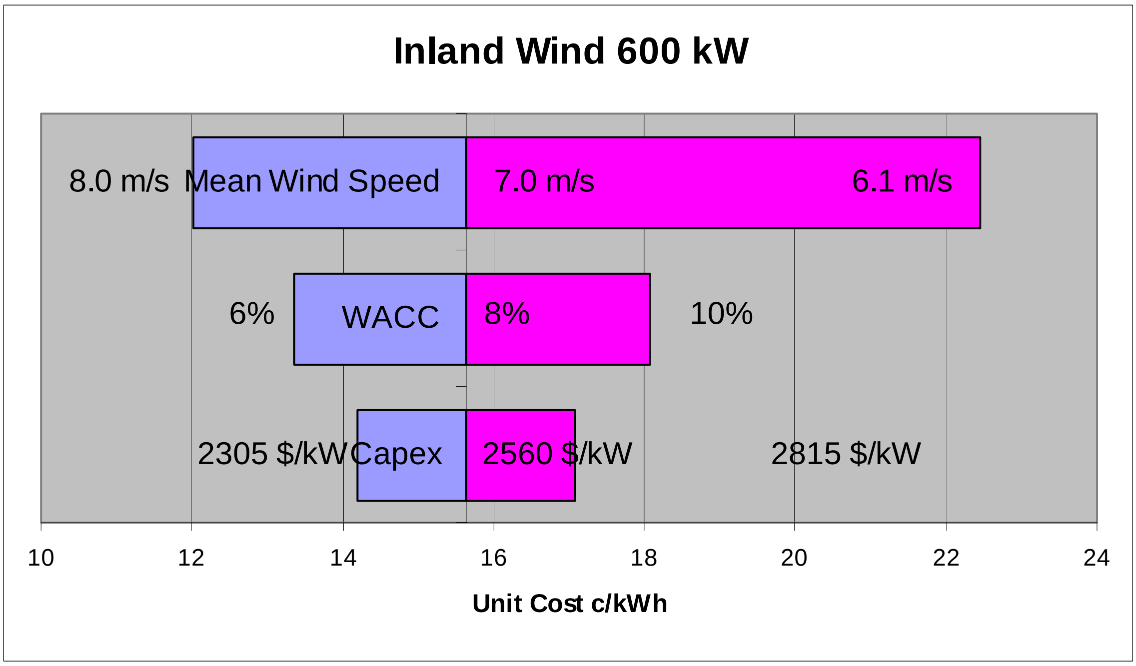


Figure A5.8

Second Hand Turbines

Second hand turbines are now becoming available in the hundreds of kilowatt range. To illustrate, the effect of halving the capital cost of a wind turbine and tower reduces the cost of electricity generation from 15.6 c/kWh for a new turbine to 10.4 c/kWh for the second hand one. The electricity cost is not halved as there are still installation costs, initial refurbishment costs, and maintenance costs which are higher and the availability slightly lower. The tornado diagram is shown in figure A5.9.

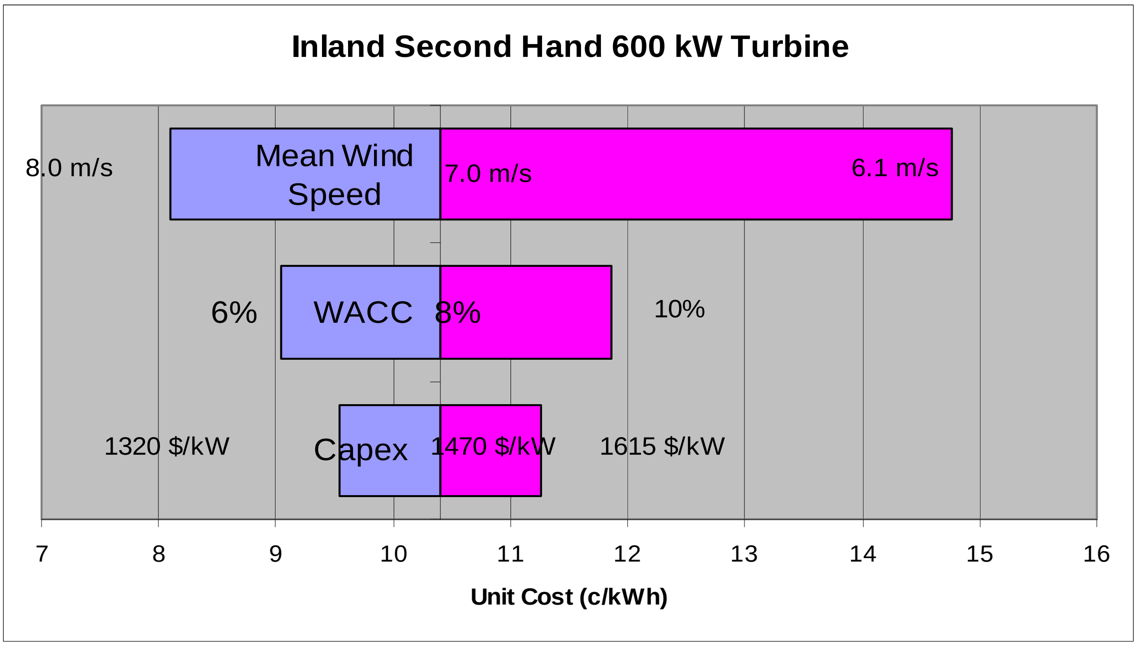


Figure A5.9

For a 225 kW installation the electricity generating cost falls to 16.8 c/kWh.

Niche Sites

For a really windy site say on the coast with an average wind speed of 9.0 m/s the electricity cost for the second hand 600kW turbine are 6.8 c/kWh and 9.5 c/kWh for the 225 kW second hand turbine.

Embedded Generation

Within the decade as wind energy costs drop it is likely that the first commercial sized wind turbines located on niche sites, such as adjacent to industrial sites at Kennington, are likely to be 600kW sized machines. Southland is fortunate that topography does not force turbines to be located in wind areas away from industrial sites.

In an embedded situation the avoided cost from generation on site is related to the variable retail price rather than the wholesale price. This significantly improves the economics.

If a wholesale wind generation market develops with turbines being located in the high wind speed areas there will be an economy of scale for the operation and maintenance of distributed wind turbines adjacent to industrial complexes.

Community Cluster

A variation of the embedded industrial application is that of a community cluster of electricity users who provide the economies of scale of installation of a large wind turbine. In all of these situations there is the need for grid connection and this increases costs so that the project economics will be reduced.

Dairy Farm Installations

Dairy farms are large users of electricity with approximately 180,000 kWh of electricity used annually on a large herd farm. Average sized farms would use around 80,000 kWh annually. Some of this electricity could be provided by installation of say 10kW turbines.

Prices for a 10kW system, which include a voltage regulator, inverter, meter, a guyed lattice tower or tilt up tower (for sites without crane access, which is available in heights of 18m to 37m range from about $56,000 to $70,000. For severe sites, an stiffer blade option is available for an additional $800. Installation costs are in additional to these.

The cost of electricity generation from such a turbine in a wind area of say 7m/s would be around 36 c/kWh. (This reduces to 26c/kWh if the average wind speed rises to 8 m/s). Against a current retail cost of electricity of around 15c/kWh it will be uneconomic for some years to come.

The cost of installation of a wind turbine on a farm for the production of electricity is usually prohibitive because of the need to connect to grid connected supply. If an islanded setup can be done instead then this can reduce costs.

Rural Water Pumping

Windmills are a traditional form of pumping water and there were once a large number of such pumps in Southland. Windmills can directly pump water through mechanical connection to the pump in which case the windmill has to be directly over the water bore, or can be used for indirect pumping were the wind mill generates electricity which is directly supplied to the pump. The advantage of indirect pumping is that the wind turbine can be optimally located with regard to wind and does not have to be directly over the water bore. As a water pumper the turbine can be located as much as 600 m from the well to take advantage of improved wind conditions.

Small wind pumpers can replace small diesel pumps from 5 - 15 Hp for either drinking water supply or irrigation.

Pumping costs from a modern 10 kW wind turbine and pump is around 30 c/kWh with an average wind speed of 7 m/s. This drops to 22c/kWh if the average wind speed rises to 8 m/s. Direct pumping can also be undertaken with traditional systems still available such as the Hayes windmill which is now sold as “The Tracker” and is (approx $5500.00 Inc GST). And windmills supplied by Ferguson Windmills Company. (Aprox $2400 Inc GST). It would appear that these traditional systems may be about a third of the cost of the new wind turbines but a fuller evaluation is required.

Appendix 6

Solar Energy

A6.1 Solar Energy In Southland

Solar energy is one of the most abundant primary energy sources in Southland. Figure A6.1 shows the solar energy intensity in Southland compared to Auckland. From the figure it can be seen that Southland is not that different than Auckland. When the difference is added to the variations in electricity saved in different applications the savings in many situations will be similar.

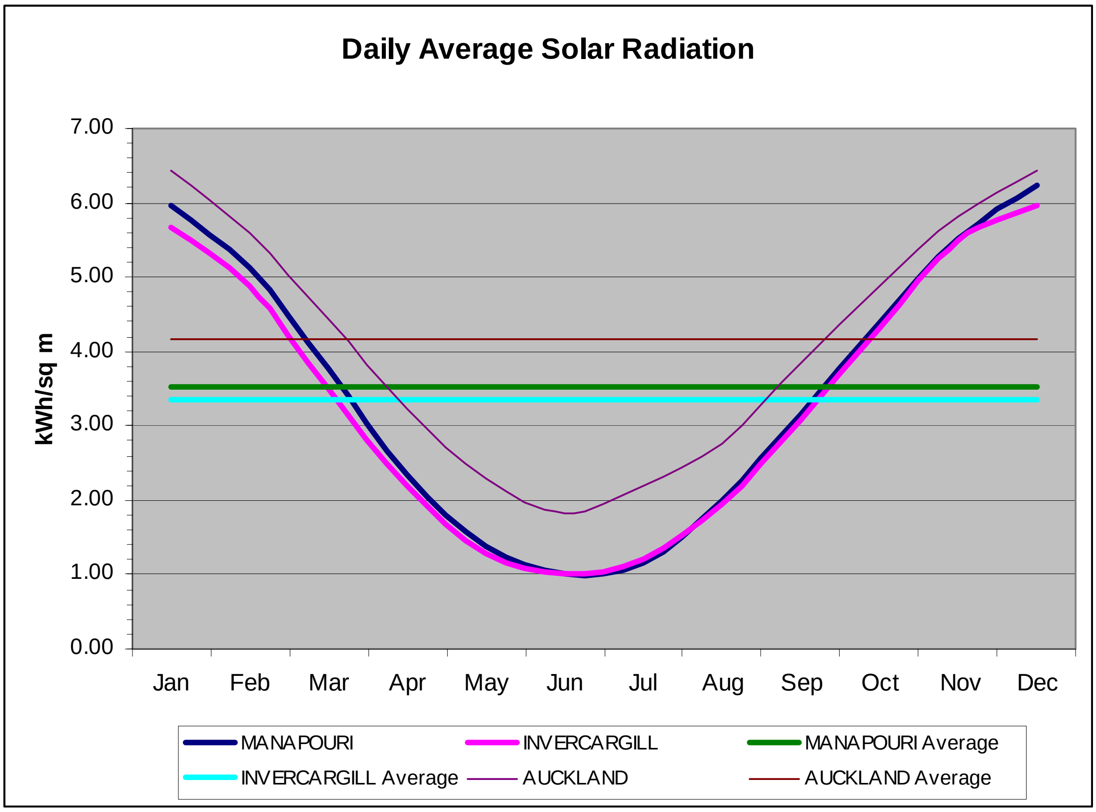


Figure A6.1 Solar energy intensity (on horizontal flat plate surface)

A6.2 Solar water heating

Heating water from solar energy is currently cost competitive relative to retail electricity tariffs throughout New Zealand and the maximum yearly output from this source is principally limited by public (home owners, builders, architects, and plumbers) perception on value of the investment. The number of systems that can be installed by either importer/suppliers or local manufacturers is adequate to match demand.

Technology

Solar heating can be grouped into low or high grade heat categories. Low grade heat (up to 120°C) collection allows the highest efficiency of utilisation of the available resource but the most limited range of applications of the stored energy. Typical applications use the low temperature heat directly for space and water heating. At the other extreme, high grade heat collection (above 120°C) has the greatest possibility of heat losses degrading performance, require more sophisticated collection technologies, but have the widest range of applications. Such applications include steam generation for driving engines and hot water sterilisation in factories.

This assessment only covers low grade heat as high grade heat is not currently economic.

The system for collecting solar energy consists of a solar panel, heat transfer system and a heated water storage cylinder. Installation of a solar system can either be with connection to existing cylinders in a retrofit application or with installation of a matched solar cylinder in a new application.

There are two principal designs for a solar system:

(a) A thermosiphon system has a storage cylinder above the solar panel and hot water moves naturally from the panel to the cylinder. In these systems the hot water cylinder has to be either with the panel on the roof or located under the roof but within the roof structure. Some systems circulate a fluid such as glycol rather than water thus eliminating frost and poor quality water problems.

(b) A pumped system allows the hot store cylinder to be located anywhere within or outside the building. An existing cylinder or a specially designed solar cylinder can be used in a pumped system. The matched solar cylinder will provide improved efficiency.

Low temperature solar water heating is an internationally mature (commercial) technology.

Although the technologies used in the flat plate type solar collector systems are relatively old, incremental improvements have occurred over most of the last 10 years in two main directions. One has led to lower costs, the other to higher system performance. In the latter case, the two main limitations in the performance of the above systems are related to the optical properties of the absorbing surfaces used (selective and non-selective), and to the relatively sizeable heat loss by convection occurring in the collectors.

Recent advances in the performance of selective surfaces for solar energy conversion have led to new industrial production of high performance selective surfaces with high solar absorptance and very low thermal emittance. This enables these surfaces to reach temperatures of 300°C and above. When these characteristics are combined with reduced convection losses, the performance of a solar collector follows a substantially improved efficiency curve.

These developments are opening up a new set of applications for solar thermal conversion operation at mid temperatures. These include commercial and industrial hot water supplies for food processing and the dairy industry, heat for sterilisation at around 85°C, and applications in heating and cooling via high efficiency refrigeration cycles operating at 150°C and above. Application of this higher temperature technology is at the demonstration stage at several European projects. So far, no application of these systems is being undertaken in New Zealand even though some evacuated tubes of this type are available here. Other approaches have been examined.

Applications

The low temperature systems available within New Zealand are generally small modular systems that can be combined in arrays to make any cumulative collector size to meet specific heating requirements. The modules are generally small and easily moveable for installation on roofs without the necessity of heavy lifting equipment. Systems are available for new installation, or installation onto existing buildings, and with use of existing hot water cylinders.

For the solar thermal industry, technical barriers have been mostly resolved, at least for low temperature conversion. Systems have existed for some time now with sufficiently high efficiency at a cost likely to yield a very positive return over their lifetime. The systems will cost substantially less over the lifetime of the system than the cost of electricity needed to produce the same output.

Solar heating technologies are modular in nature and are therefore adaptable to a variety of applications that vary in size, output temperatures and other operating requirements.

There is a lack of adequate information to ensure public awareness of the technology and its advantages. This lack of awareness spreads through to all sectors of this industry.

Presently available glazed flat plate systems are mostly limited to operating temperatures below 60^{o}C in order to maintain a relatively high conversion efficiency. While in relatively common use for domestic water heating, commercial or industrial scale collectors have so far not been widely adopted, despite recent advances and technical feasibility. It is noticed however that with the current resurgence of solar energy that new applications are arising such as the use of solar energy as a preheater for wood kiln drying.

A benefit of solar heating lies in it being a distributed energy supply system that is independent of the costs of a central energy supply network. The failure of one solar water heating system may be a problem to one user, but will not affect an entire city or the nation.

The pumped system can be connected to existing hot water storage cylinders and are therefore cost effective when retrofitting on to an existing house, motel, rest-home etc. Both pumped and thermosiphon systems are appropriate when a new structure is being built or an existing hot water cylinder requires replacement, or if additional hot water storage is required in which instance the system is installed as a pre-heater.

Pumped systems are very versatile as the hot water storage cylinder can be located anywhere in or outside a building.

From an economic standpoint, retrofits to existing homes for thermosiphon systems do not benefit from savings in the construction costs that new installations would occasion. At an average cost of around $2500 to $5000 for a full installation in a residential home, these systems would be most economic when replacement of existing hot water cylinder is required. On the other hand thermosiphon systems have the advantage that they can be expressly independent of electricity, although usually they still have an electric or gas secondary heating element to provide backup heating of the hot water, or a solid fuel stove (wetback) may also be fitted.

The technology has a large potential for cost reduction in the near future due to technological advances and increased production based on substantial market expansion. Market expansion will also result in improved results from marketing. Currently market initiatives are focussed on creating a market. With an expanded market solar system suppliers would be undertaking promotion within a market. It has been assessed that with a larger market costs could easily drop around 20% within ten years.

Barriers

The main immediate markets for solar water heating in New Zealand are the residential and commercial building industries.

The main cost barrier to the dissemination of solar technologies is ostensibly their initial capital cost to the users.

The building industry's traditional conservatism towards solar systems (and that of associated trades and professions, i.e. builders, carpenters, plumbers, architects), their lack of awareness, understanding, and experience of solar water heating constitute a major barrier to adoption of the technology.

As distinct from other renewable technologies solar heating requires the end user to make the capital investment. Capital cost can therefore be a barrier to uptake. On the other hand it is also the situation where the investor directly secures the benefits.

For commercial and industrial use, the availability of the resource through location and specific heating requirements will affect the financial suitability of solar water heating.

Solar technologies are easily integrated into new or existing buildings, they can be unobtrusive, can enhance the aesthetics and architectural appeal of buildings, and can be considered a positive asset due to their green image however more generally installation of solar heating currently is not perceived by house buyers to add value to the price of a house. It is not sufficiently valued at national and regional levels or in regulations and standards, hence has little or no marketable value at present. This is an issue that can be addressed by regional initiatives at a Council level particularly through the proposed method of building energy rating currently being developed in Christchurch. This will enable purchasers to assess the benefits of the energy options fitted to a building in the same way that a purchaser would take rates (for instance) into account.

Environmental

In use, solar technologies do not contribute to any known form of pollution (air, land, water) or greenhouse gas emission.

Solar energy is distributed right across the country, requiring neither transportation nor any special infrastructure for its use. It can be collected at its location of use.

Solar water heating can reduce the market demand for electricity and as a result marginal thermal electricity generation.

Economics

It is difficult to assess the economics of solar hot water as each application is different. The location and orientation of the system, time of year, and method and time of hot water use can all affect the benefits.

Solar systems in a residential application are usually sized so that about 75% of annual hot water requirement is contributed by solar energy. Aiming at 100% would result in the system be oversized for large parts of the year and the capital cost would not be optimised. In a commercial / industrial application where there is a large steady hot water demand a greater contribution may be sought from solar energy.

In a residential application hot water can be delivered at around 8-10c/kWh and in a large commercial/industrial application around 6-9 c/kWh and for a dairy farm 7-9 c/kWh. There are over 300 new building consents issued in Southland each year. If 80% of new residential buildings and 5% of existing residential dwellings had solar water heating systems installed each year this could result in 1950 systems being installed each year which would result in 4.9 GWh of electricity savings.

A6.3 Photovoltaic

Solar energy can currently be converted into electricity at a cost suitable for small niche uses. Photovoltaic (PV) electricity is already well established in stand alone applications in remote areas. However the technology is rapidly advancing, and an increasing proportion will be taken up for other applications over the next two decades.

Economics

As a rule of thumb, the solar module represents 40-50% of the total installed cost of a "solar system". This percentage will vary according to the nature of the application. A complete solar system includes all the other components required to create a functioning system, whether it be to feed energy in to the grid or to be used in stand alone off-grid applications. In 2003, a residential solar system costs about $16,000-$24,000 per kWp installed.

Currently, PV generated electricity costs around 60c/kWh. However, the unit cost is dropping rapidly such that over the period to 2025, PV is likely to mature and enter the domestic-level grid-connected market. As such, PV will be competing against the retail cost of electricity rather than wholesale alternatives.

It is assessed that in Southland by 2012 and based on current technology the unit cost will be in the 31-48c/kWh range, and by 2025 in the 14-21 c/kWh range.

The main impediment to further uptake of PV technology has been its cost compared to grid electricity prices.

Technology

Direct solar to electricity conversion can be carried out with photovoltaic cells. These are usually solid-state semiconductors that generate an electrical potential when exposed to light. These cells are made from a variety of semiconducting materials either in single crystal form (silicon, gallium arsenide (GaAs), indium phosphide), in multicrystalline and polycrystalline form (silicon, cadmium telluride (CdTe), copper indium gallium diselenide (CIGS)) or in amorphous form (silicon, silicon-germanium alloys). In each the laboratory and commercial production techniques differ, with differing performance resulting. Only a small number of cell designs have reached industrial production.

Most industrially produced cells are silicon with efficiencies of around 15% (versus lab efficiencies of up to 24.5%).

About 60% of current production is based on single crystal flat plate technology, 25% on polycrystalline silicon technology, and 11% on amorphous silicon technology.

For complete functionality, PV modules require various components such as the structural supports, charge controllers, inverters, batteries and safety disconnects. There may be special metering requirements where export may occur.

Applications

The main applications can be divided into four broad sectors (including two distinct types of grid-connected systems):

- Consumer products – These (after space applications) were the first commercial applications of PV e.g. calculators, watches, toys. They also included individual power supplies (caravans, mobile homes, boats) and individual supplies for novelty products (home security, garden lighting, car sunroofs, fans and battery chargers).
- Industry applications – PV systems can be sold to a service industry, especially “professional systems” provided by companies active in the communication industry and the cathodic protection industry. New Zealand’s electric fence industry is a substantial and good example.
- Standalone Power System (RAPS) applications – These are applications in the watts to kilowatt size range located at sites remote from the main distribution grid. This will be a pivotal growth area in a number of countries for applications like water pumping, water treatment, electric supply to small industry, domestic/medical/institutional uses and communications links.
- Grid connected distributed supply system applications – These are a newer but vigorously growing example of PV use in the urban environment. These systems are simpler than RAPS as they require only PV panels and inverter to provide AC voltage and connect to the local distribution grid. The main electricity supply acts as a storage facility, receiving electricity at times of PV surplus and supplying it at times of PV deficiency, hence there is no need for a battery system. Agreements and standards for electricity transfer in both directions on and off the site are usually required. These systems provide electricity at the consumer end of the distribution chain and compete with the retail price of electricity. (A variation on this has been investigated in the US where utilities will install systems in neighbourhoods, relieving local distribution networks but largely competing at the wholesale end of the market).
- Grid connected power plant applications – These have been trialled overseas to a size of >1MW. These include both full scale central PV stations feeding power to the distribution grid, and embedded generation PV systems used to correct either overloads or degraded power quality at critical points, (thus deferring substantial capital and maintenance expenditures on transformers, lines etc). A very successful illustration of this embedded application is found in the Kalbarri 20kW PV system in Western Australia. (These applications include both utility-scale, flat-plate thin film PV and concentrating PV).

Technical Status

PV has been commercialised in specialist small-scale applications since the 1970’s. First trials of MW-sized utility systems were installed in the 1980’s. Several countries have large-scale demonstration plants, but growth and the bulk of capacity are at the domestic and commercial level with an increasing proportion being grid-connected.

Systems are reliable such that PV modules carry a manufacturer's guarantee of 20 years.

The PV industry appears to have reached a critical level such that sales are increasing rapidly allowing large-scale manufacture with associated price reduction. This in turn is boosting demand.

A trend in the PV industry worldwide has been the involvement of all major petroleum companies in the ownership, direct production and promotion of solar energy, especially PV electricity production. This has seen recent company amalgamations, and the establishment of larger scale PV production plants (10 to 100MW/year) in Australia, Europe and USA which may realise substantial economies of scale. These large plants have been developed on the assumption of an explosion in demand in the near-term estimated in the range 30 to 45% per year for an indefinite period. A more conservative industry view would place long term growth at 25% per year.

Several laboratory technologies are being transferred to industry (e.g. laser grooved buried contact patterning, single crystal silicon, production of large thin films) with consequent efficiency gains or reduced cost due to less material and lower production costs.

It is likely that PV technology will continue to enjoy spin off benefits from developments in the microelectronic industries generally. The current worldwide investment in new materials and devices by these industries is very large and technological breakthroughs applicable to PV systems are likely.

PV power systems are versatile as to their size and power output, from microwatts for calculators to megawatts and larger for central grid connected power stations. System availability should be quite high (85-95%) and maintenance needs will be modest.

Out of Australia, there are packaged PV and PV/diesel hybrid systems in the kW load range from a number of suppliers.

PV is the energy source of choice for navigation lights, telecom sites and isolated or remote areas (including Antarctica) where reliability and low maintenance are of the utmost importance.

The PV industry in New Zealand comprises mainly distributors of imported modules and a network of equipment installers. Some ancillary equipment is made locally. There is no PV manufacturing capability in New Zealand.

The New Zealand oil companies Shell and BP, as well as Canon, have published their intention to import and supply PV modules and systems in New Zealand. BP already have PV systems installed on 11 petrol service stations throughout New Zealand.

Some technical developments in building electrical systems may be beneficial to PV power installations. For example, low voltage, direct current lighting systems could form ideal loads for PV systems and remove the need for inverters thus improving the overall economics.

One niche market for PV in New Zealand has been for electric fence applications. Rural uptake could extend further after 2013 when electricity distribution companies are no longer obliged to maintain rural supplies.

Environmental

PV has low environmental impact so is very attractive. Full lifecycle analysis does indicate surprisingly high carbon emissions mainly associated with the processing of the raw materials.

This technology is regarded as one of the most attractive green technologies.

PV systems are easily integrated into new or existing buildings, they are unobtrusive, can enhance the aesthetics and architectural appeal of buildings and are often considered a positive asset due to their green image.

A6.4 Solar Space Heating

A major energy saving benefit can be achieved in any building if it is designed to maximise the absorption of solar energy. This is best done prior to construction when the building is being designed.

It is difficult to quantify the energy saving benefits achievable however the value can be intangibly recognised in the building resale value.

The main barrier to greater consideration being taken of solar space heating is lack of information and role models. It is often perceived that solar space heating can only be considered for expensive residential buildings when in reality it can apply to every building.

This is an area where promotion of solar space heating and the demonstration of role models can have a significant influence on uptake.

A6.5 Solar Thermal Systems Producing Electricity

Currently solar thermal systems for the production of electricity are still in the experimental stages of development and no realistic costs of electricity production are available.

This is an area which will have greater importance over the next two decades and it should be monitored appropriately.

Appendix 7

Coal / Lignite

A7.1 Coal /Lignite Reserves in Southland

Coalfields in Southland include the extensive lignite deposits underlying the Eastern Southland Plains and Maitland Basin, the small Hedgehope Coalfield in Eastern Southland, and Ohai and Orepuki coalfields plus a number of minor coal deposits in Western Southland. These fields are shown in figure A7.1 and the quantities of recoverable reserve in table A7.1. These represent just over 70% of New Zealand's coal reserves in tonnes or just over 60% in energy terms.

Source MED

Figure A7.1 Coalfields of Southland

Coalfield	Coal Rank	Measured		Indicated		Inferred		Total	
		Mt	**PJ 000**	**Mt**	**PJ 000**	**Mt**	**PJ 000**	**Mt**	**PJ 000**
Gore	Lignite	0	0.00	205	2.38	39	0.45	244	2.83
Croydon	Lignite	0	0.00	333	3.87	0	0.00	333	3.87
Waimumu	Lignite	0	0.0	233	2.71	0	0.0	233	2.71
Mataura	Lignite	0	0	1945	22.58	0	0.00	1945	22.58
Edendale	Lignite	0	0.00	290	3.37	205	2.38	495	5.75
Morton Mains	Lignite	0	0.00	547	6.35	0	0.00	547	6.35
Waimatua	Lignite	0	0.00	834	9.69	0	0.00	834	9.69
Ashers Waituna	Lignite	0	0.00	746	8.64	0	0.00	746	8.64
Makarewa	Lignite	0	0.00	563	6.54	258	3.00	821	9.53
Ohai and Orepuki	Sub Bituminous	0.76	0.02	37.3	0.75	20.4	0.41	59.2	1.18
TOTAL Southland		**0.76**	**0.02**	**5,733**	**66.9**	**522.4**	**6.2**	**6,257**	**73.1**
TOTAL New Zealand		**570.7**	**9.5**	**7213.6**	**94.2**	**860.2**	**14.1**	**8645**	**117.9**

Note: Some totals are not exact due to rounding

Source MED
Table A7.1 Recoverable Coal Resource

The coal and lignite fields are all multi-sean resources however in most fields a major proportion of the recoverable coal or lignite is in one to three seams which are often greater than 10m thick. Much of the reserves have a relatively low overburden ratio and the coal or lignite can be recovered by open cast extraction.

In the 1980's the Liquid Fuels Trust Board undertook extensive investigation of the more significant fields to supply both electricity production and a synthetic petrol facility.

Coal and lignite extraction has been limited because of lack of a market rather than any difficulty with extracting the resource.

A key aspect about extraction of coal and lignites from the various fields has been the high proportion of unsaleable coal fines that have had to be stockpiled. In some fields this can be up to 15% of the resource extracted. Finding a use for the coal fines should be a priority for the region. Electricity generation is a suitable use for coal fines. Pelletisation of the fines would provide a fuel suitable for most industrial boilers.

Suppliers

There is a very active coal market with two principal suppliers;
Solid Energy
Solid Energy is New Zealands biggest coal supplier and has been operating the Ohai fields for a number of years. The quantity of coal and lignite reserves that they can access would keep a major user going for a number of years. Solid Energy has the experience and capabilities to supply virtually any quantity of coal or lignite and have been investigating construction of electricity generation plant either as a standalone facility, or a cogeneration plant for supply also of heat to a major energy user.

New Vale Coal Company
With the purchase of the Goodwin Coal Mine New Vale Coal Company Limited now have access to 14 million tonnes of coal and lignite reserves. New Vale Coal, 28km west of Gore, has been in operation for more than 60 years and is family owned and operated - the largest privately-owned coal mine in New Zealand. Industrial clients for the coal include freezing works, dairy factories, hospitals, schools and swimming pools. Current sales reach almost 200,000 tonnes per year.

There are a number of other small mining operations such as at Ashers and Waituna.

Mining

There is no environmental constraints on mining that are known to the authors of this assessment. While there are clearly groundwater and run-off issues that have to be addressed there are standard procedures for managing these. In addition the resource consent conditions will set environmental standards that will have to be met.

Wholesale Electricity from Lignite

An indicative cost of generating electricity from a 150 MW unit using lignite fuel is 6.8c/kWh. This is based on a 20 year life, load factor of 90%, fuel cost of $1.5/GJ (delivered and with an allowance for a Climate Charge) and 8% WACC. Calorific value is 14 MJ/kg and moisture content 40%. 800,000 tonnes of lignite would be burnt each year. Transmission costs would be in additional to the cost of production. The tornado diagram in Figure A7.2 illustrates the sensitivities of the electricity cost to size of plant, capex, fuel cost and WACC.

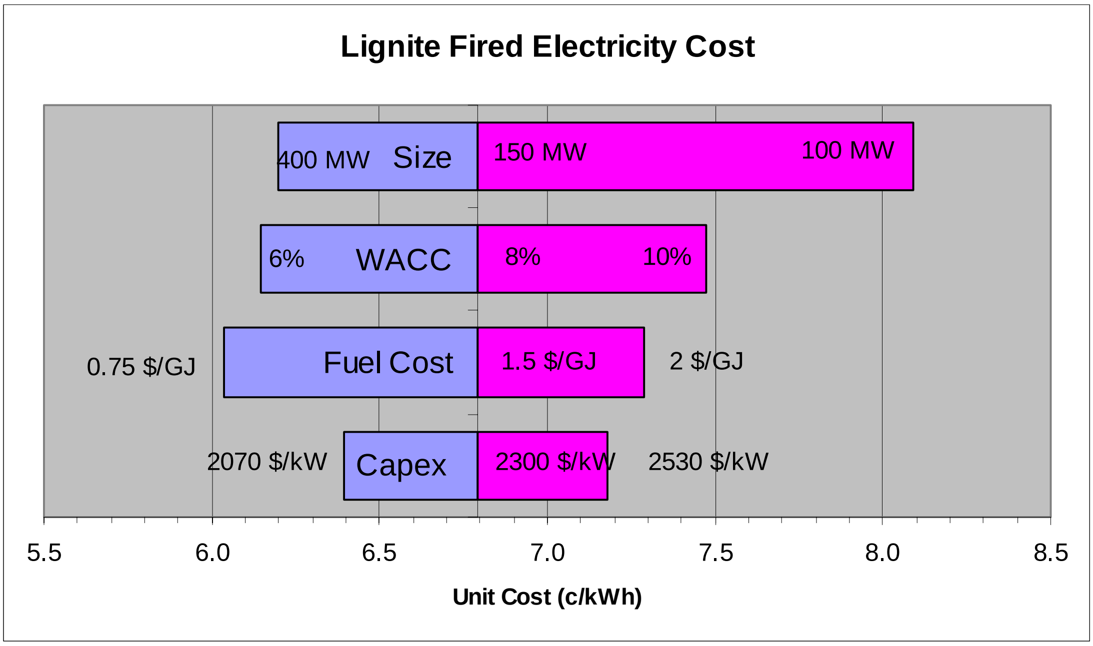


Figure A7.2

Wholesale Electricity from Coal

The sub-bituminous coal resource is much smaller than the lignite. As it is a higher rank coal with one and a half times or more the calorific value of the lignite it was considered to be a more valuable resource in the region and is more likely to be used for niche activities such as a fuel in industrial cogeneration plant. The lignites could be developed for electricity generation.

Alternative Fuels From Coal

Research into the upgrading of coal particularly low rank coal such as lignite is being carried out world wide. Some of this research concentrates on the reduction of the water content of the coal to reduce transport costs, lower boiler capital costs and improve efficiencies.

Other research involves gasification and liquefaction of coal. These technologies were investigated by the Liquid Fuels Trust Board in the 1970s and 80s. At present there are several demonstration coal gasification plants in existence but the technology is not commercial as yet. Gasification enables the coal gas to be used in high efficiency combined cycle gas turbine plant.

Small Scale Cogeneration of Electricity

The availability of coal and lignite in Southland provides an opportunity for cogeneration of electricity and heat for industrial sites. The coal or lignite could be used as a fuel by itself or co-fired with wood waste.

In the case of a 10 MW lignite/coal fired boiler feeding all the steam into a 2.6 MW second hand steam turbine generator would result in electricity being produced at a cost of 11-13c/kWh. Use of a new steam turbine generator would increase the cost of electricity very significantly.

Increasing the size of the cogeneration plant at the milk factory at Edendale could be an opportunity to reduce their reliance on electricity and perhaps provide some “reserve” generation capacity in the event of a dry hydro year.

Environmental

Production of electricity from a coal fired power station can be done so that there is no adverse environmental effects. Good design and proper cleam-up of air emissions can ensure that a coal fired power station can be built adjacent to communities. The Huntly power station in the North Island is a good example of how a power station can be located adjacent to a significantly sized community with no adverse effects.

An image of coal fired power stations often derives from older powerstations in Europe which were built without proper air emission clean-up facilities. Such plant would not be acceptable and would not be proposed by developers.

Appendix 8

Hydro Energy

Today's environment for hydroelectric development is very different from that which applied during the 1960s to 1980s when most investigations of the hydro energy potential in Southland was undertaken. These investigations were undertaken by or for state owned agencies who had a need to "meet demand". This regime no longer applies; opportunities are now investigated by investors who are commercially driven. These changes affect the public acceptability of new hydro projects.

Public acceptance of a potential hydroelectric development is also more difficult today due to society's changing environmental and conservation attitudes. The statutory approval requirements through the Resource Management Act are more transparent, stringent and have a lower certainty of success. However, this should by no means preclude hydroelectric development from consideration as a future energy source. There are many opportunities that are considered to be quite consentable, if a robust consenting process is followed. It does however require all participants to consider potential projects with an open mind.

Many schemes previously considered to be not viable for economic or environmental reasons may be now viable by the adoption of a different technical and commercial approach, e.g. water extraction rather than river impoundment.

There is a significant level of hydro opportunity that is technically available within Southland. However, technical feasibility has to be balanced with economics and consentability.

This assessment includes run of river and out of river schemes but does not include pumped storage (as there are no known sites available in Southland), or potential projects under 3 MW.

Technology

Hydropower technology is a proven commercial and mature technology. The conceptual use of the technology is however being continually refined, i.e. better techniques for site selection, plant design and construction; innovative civil works, e.g. modular design (particularly for remote sites), improved generating plant and controls, and standardisation of equipment. Improvements in turbines, draft tubes, and reducing headrace and tailrace restrictions have revitalised old marginal stations and improved power output from others. Embedment benefits are significantly enhanced with schemes that have water storage capacity.

Multi Use Applications

Hydroelectric generation projects can be developed with irrigation projects, flood protection schemes, and community water supplies etc which can result in multiple community benefits.

Along with consumptive uses such as irrigation and water supply, New Zealand's fresh water resources are a resource strongly associated with recreational activities ranging from swimming, water skiing, jet skiing and flat water canoeing to white-water rafting, canoeing, and jet boating. Fishing and fisheries, both recreational and commercial are also very significant users of fresh water as are flora and fauna.

Unlike most other energy sources, hydro generation can be combined with these other community uses, and through shared infrastructure, project economics and maximised community benefits can be achieved. In many cases the hydro generation triggers the achievement of community benefits which would not otherwise be achievable without the commercial driver of electricity generation.

The balance between commercial and community benefits/costs of any hydro scheme are determined more or less by the resource consent requirements under the Resource Management Act.

Concept/Design

Significant advances have been achieved in recent years in lowering the cost of generation from hydro schemes. This is attributable to a number of factors such as a move away from a philosophy of maximising resource utilisation (i.e. high installed capacity/low plant factor) to one of optimising unit cost of generation, lower costs of generation equipment, more cost effective design, technological advances in both the permanent works design and construction equipment and productivities, multiple community benefits, and a more competitive construction industry.

In Southland hydro investigations were last undertaken in the 1980s and the potential schemes identified in those investigations have not been subject to this new conceptual approach. There have been few hydro investigations undertaken in recent years.

Today, scheme concept and design will generally be based on the level of residual flow that will be required to be maintained in the river during times of water storage or power station operation. In recent years the residual flow requirements have increased with a resultant decrease in both potential generation capacity and associated economics.

Irrigation schemes and hydroelectric generation schemes can be complementary uses of a water resource and when combined can increase the overall value of that resource. Provision of irrigation also has the potential to contribute significantly to the local community support for the project and hence to its consentability. The evaluation of the irrigation potential is very dependent on local factors such as soil type, rainfall patterns and the potential to modify the land use.

The main critical factors are resource location, engineering and environmental issues. Remote locations increase construction costs including transmission line costs and power losses. Location plus head, flow, geological conditions, etc. affect the cost per installed capacity. Flow, storage and capacity choice affect capacity factor, or degree of utilisation, the other key economic element.

Although obtaining resource consents will be a significant feature of any future hydroelectric development, many of the identified opportunities are considered to be realistically consentable if a sound public consultation programme is undertaken that enables interaction with the community in clearly defining the effects, and establishing a range of possible measures to mitigate the adverse effects.

Environmental

Internationally, there is some resistance to hydro development as it often involves flooding of large areas of land. As the potential hydro schemes available in Southland do not involve flooding great areas, these international concerns are not transportable to Southland.

Hydroelectric generation is mostly seen as a clean and non-polluting means of producing electricity using a renewable resource. It is generally a safe electricity generation source with only a few significant failures internationally. Land stability and induced seismicity may be issues.

Hydro development does, however, alter the nature of rivers and modify or prevent other uses and values of the river such as scenic values, fish use, wildlife habitats and some recreational uses. Sediment balances can be altered and ecological effects may extend to coastal environments. Increased residence time from impoundment can create water quality problems, especially where inflows carry high nutrient loads.

At the same time hydropower development creates new recreational facilities, different habitats, and form new water features which may contribute to landscape values. Construction impacts potentially can affect local communities; however these can be managed and townships can be left with improved community facilities.

Development is a matter of balancing the losses with the gains. Success often depends on good public consultation and involvement.

Southland Hydro Resource

The Southland region has vast hydro potential but most of it is within the Fiordland National Park. The balance of the region has only two significant catchments, the Waiau and the Mataura, with some smaller opportunities in the Oreti.

The flow in the Waiau River is largely dependent on the generation requirements of the Manapouri power station although the Manapouri resource consent sets a minimum flow condition of 12 (winter) and 16 (summer) m^3/s at the Manapouri (Mararoa) Control Structure . The river has a mean flow of 34.2 m^3/s at Sunnyside.

Lake Te Anau water flows into Lake Manapouri via the upper Waiau river and the gates at Te Anau. There is a head difference of about 20 m between the lakes and this could be used for electricity generation. Also at the Mararoa weir water from the Mararoa River is diverted into Lake Manapouri. The weir has a small head difference which could be used for electricity generation.

The water from Lake Monowai passes through the Monowai power station. Additional energy can be obtained from this resource by diverting water from the nearby Borland River .

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Source: Environment Southland

Figure A8.1 Waiau Catchment

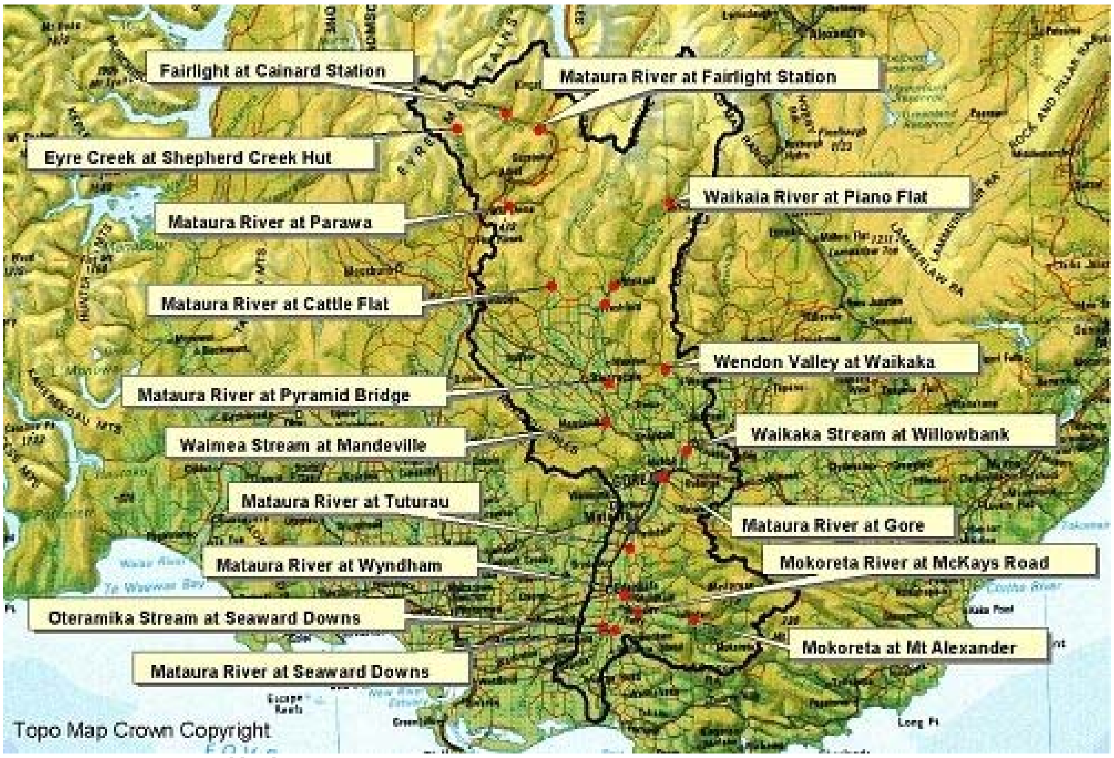
Within the Fiordland National Park there is a hydro scheme which was previously investigated based on the 125m head difference between Lakes Hauroko and Lake Poteriteri. An alternative scheme uses the head between Lake Hauroko and Te Waewae Bay

The Mataura catchment is currently fully protected by a Water Conservation Order which prohibits damming of the Mataura and Wakaia for electricity generation. The river has a mean flow of 51.3 m^3/s at Gore.

The Mataura Water Conservation Order was considered in a different era and as a result the Order covers practically the whole catchment. Recent Water Conservation Orders were more discretionary and only those parts of the river that fully deserved to be locked up were covered by the order. On those rivers there are lengths of river in which other uses are permitted. It is suggested that the Order should be revisited so that the Order covers only those parts of the catchment that deserve preservation.

The Oreti river has a mean flow of 29.1 m3/s at Wallacetown.

Lake Wakatipu periodically floods and causes significant damage to Queenstown. It has been mooted but never investigated that a canal could be dug from Kingston to Garston and flood water diverted from Lake Wakatipu into the Mataura river.



Source: Environment Southland

Figure A8.2 Mataura Catchment

Southland Hydro Opportunities

A comprehensive study of the hydro potential specifically of the region was undertaken in 1983 and of the whole of New Zealand in 1990.

It is assessed that there could be around 70-120MW of hydro electric projects in the region producing around 570GWh at costs of generation estimated as between 8-15c/KWh.

Lower Waiau Canal Hydro
It may be possible to develop a project aqua type hydro generation scheme in parts of the lower Waiau catchment. This would entail extraction of some flow from the main stream of the river and running this along canals to a power station where it would come back into the river. If a 12 MW scheme were built it could produce around 55 GWh and produce electricity at around 7.5-9c/kWh.This has not been investigated but indications are that it may be possible.

Upgrade Monowai power station
The existing Monowai power station has a capacity of 6.3MW and produces 35-40GWh of electricity per annum. Resource consents have recently been obtained for continued operation of the station. Options for additional flow from the Borland and additional generation using the existing flow have been identified but are not currently considered economic. There may also be environmental issues relating to the Borland option.

Lake Monowai storage could also be coupled with a nearby windfarm to firm the wind energy.

Upper Mararoa
Schemes have previously been considered on the upper Mararoa. Without site investigation it is unknown whether these are viable.

Mararoa Weir
The Mararoa Weir has a small head which could be utilized for generation of electricity using the residual flow. As the structure already has the capacity to handle diversion flood water there would be little need for structures, only a penstock and turbine/generator.

Te Anau gates
There is about 20m head difference between Lakes Te Anau and Manapouri. This head can be utilized for generation of electricity by either an in river low embankment/powerhouse scheme or by construction of a tunnel to a powerhouse on the shore of Lake Manapouri. Either of these schemes could have an installed capacity of around 65 MW (350 GWh) at a cost of generation of 8-10c/kWh. The area is on the edge of the National Park so care in design to protect the Park area would be necessary.

Waikaia
The Waikaia river tributary of the Mataura offers potential for a 400m head scheme developing 15 MW (70 GWh) from a tunnel diversion. It is assessed that electricity could be generated at around 10-15c/kWh

Mataura Canal Hydro
Although previous studies emphasised the potential of dams built in gorges it may be possible to develop a project aqua type hydro generation scheme in parts of the Mataura catchment. This would entail extraction of some flow from the main stream of the river and running this along canals to a power station where it would come back into the river. An aqua type canal project could be around 6MW and produce 30-35Gwh at between 8-12 c/kWh.

Oreti Canal Hydro
As for the Mataura it may be possible to develop a project aqua type hydro generation scheme in parts of the Oreti catchment. This would entail extraction of some flow from the main stream of the river and running this along canals to a power station where it would come back into the river. An aqua type canal project could be around 6MW and produce 30-35GWh at between 8-12 c/kWh.

Lake Hauroko
While this project is within the National Park, the successful expansion of the Manapouri power station has shown that hydro projects can be constructed in National Parks without adversely affecting the environmental qualities. Lake Hauroko is approximately 125 m head above Lake Poteriteri and by use of a tunnel and underground power station this head could be used to generate electricity. An alternative is a scheme that uses the head of about 160 m between Lake Hauroko and Te Waewae Bay. In either case a residual flow regime for the Wairaurahiri River would need to be incorporated in any development.

Lake Wakatipu Flood Alleviation
The head difference between Lake Wakatipu and the Mataura River near Garston is about 5 m. This would be adequate so that when Lake Wakatipu floods water can be diverted into the Mataura River. This diversion would be in the old lake outlet but would have to be under conditions which would allow the diversion of water to occur while avoiding flooding in the Mataura. Such a scheme could only proceed after full community

consultation including Maori because of the diversion of water from one catchment into another.

By careful design the Lake Wakatipu water may be able to be taken through a long enough canal that could result in electricity generation. Alternatively wind energy may be able to be used to pump water from Lake Whakatipu into the Oreiti for water augmentation.

Manapouri / Monowai Wind
The existing Manapouri and Monowai lake storage provides an ideal buffer for increasing the value of wind energy. Wind energy often occurs at times of low value. This value can be increased significantly if the wind generation is coupled with hydro storage. This can allow the sale of firm electricity.

Barriers

The most significant barrier to any of the schemes possible in Southland is potential environmental effects. The schemes referred to are all technically possible but the mitigation measures that may have to be taken for some schemes may increase the costs so that they are uneconomic. The potential environmental effects of the schemes listed are however possibly less significant than is likely with many other alternative projects that may have to be considered within the next decade if the community wishes to increase energy use.

The ability to acquire the rights (purchase, easement, etc.) to the land necessary for the scheme is a significant potential constraint. The situation relating to land has changed in that, prior to 1987, Government policy was that farm land should not be flooded for the purposes of hydroelectric development, whereas today, that policy no longer applies. As is evident from the 1983 study, this has resulted in hydro-electric investigations not considering a number of potential schemes solely on the basis of this policy. Today the greater difficulty relates to protection of residual flows, and avoiding encroachment on native forest land that has been protected by various means.

Hydro Pricing

There is a growing demand for water for urban supply and irrigation and multi-use water projects are expected to become more prevalent in line with international trends. The value of water generally is showing a rapidly increasing trend. It is expected that the multi-use approach has the potential to improve the economic viability of many hydroelectric generation projects. It has the added benefit of winning local community support and thereby being a major benefit in achieving resource consents.

As there is little storage associated with any of the potential hydro schemes the price received for generation will generally be related to spot market prices. The schemes will therefore be price followers with little opportunity to optimise revenue. The exception will be if the schemes are able to be embedded into an industrial users electricity demand management system.

As has already been mentioned the water at Lakes Manapouri and Monowai, when coupled with wind energy so that the water storage is treated as a battery for uncontrolled wind energy, can provide greater value for the wind energy. This may be adequate enough to allow firm supply contracts from a wind farm.

Comment

The hydro electricity generation potential of Southland is around 70-120 MW generating around 570GWh per annum and ranging in generation costs estimated as between 8-15 c/kWh. This is a significant source of energy which may have less long term adverse environmental and societal effects than many other alternative sources of energy.

The expansion of the Manapouri power station has demonstrated that hydro electricity generation facilities can be constructed in environmentally acceptable ways, while still commercially acceptable. To achieve this requires developers to undertake extensive investigation and sound consultation with effected parties. This is expensive and there is no guarantee, that despite the expenditure of large sums of money, that resource consents will be achieved. For new hydro energy projects to be even considered in the future it is necessary that a more receptive community attitude to hydro energy be developed.

The possible Southland schemes range from run-of-river which produces base load electricity, to small niche schemes that are suitable for embedded generation similar to that of the existing 0.8 MW Mataura hydro power station.

Hydro energy is a premium source of electricity because it is controllable and responds fast enough to ensure supply security when incidents occur in the electricity system.. If the hydro energy is coupled with less flexible or less reliable energy such as wind, then the value of both can be optimized.

Appendix 9

Bioenergy

Biomass can be considered as solar energy stored in the chemical bonds between the carbon, hydrogen and oxygen that make up plant material (cellulose, hemicellulose and lignin). Biomass can take many forms. While agricultural products are used as biomass fuels overseas, their potential within NZ is limited and other than sugar beet which is covered in Appendix 12, they have been excluded from this assessment. This assessment focuses on the abundant woody biomass stock and its use.

New Zealand's climate and soils are ideal for biomass production.

A9.1 Woody Biomass

Bioenergy Resource

Woody biomass for use as an energy feedstock comes from a number of sources;

- **Forestry residue** - slash, tops and unmerchantable stemwood from trees harvested for saw or pulp logs. Forest residue may include the cutover depending on location of harvest.
- **Wood processing residues** – bark, sawdust, shavings, offcuts, etc. from processed wood for pulp, panel board, construction timber, furniture, etc.
- **Woody crop plantations** – short rotation crops grown specifically for energy purposes, possibly in associated with land disposal of sewage and industrial effluent.
- **Scavenged firewood** - from dead trees, prunings, tree removal and a range of other sources used as firewood.

Net stocked planted production forest by territorial authority as at 1 April 2002.

Territorial Authority	Area (ha)	Standing volume (000 m3)	Area-weighted average age (years)
Southland District	79 426	8 655	10.70
Gore District	3 371	262	7.58
Invercargill City	823	251	18.22
Total Southland	**83 720**	**9 167**	
Total Otago & Southland	**207 525**	**29 152**	**12.02**
South Island total	**532 920**	**85 721**	**13.49**
New Zealand total	**1 814 266**	**389 800**	**13.56**

Source: MAF

Table A9.1 Area, Standing Volume and Area-Weighted Average Age

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When considering woody biomass energy some useful values to consider are (EECA 2001):

Typical pine wood green density = 1,065 kg/m^3

Calorific value of biomass from processing facilities = approx. 13 MJ/kg

Calorific value of biomass from forest residues = approx. 9 MJ/kg

Forested areas in Southland are shown on the figure A9.1.

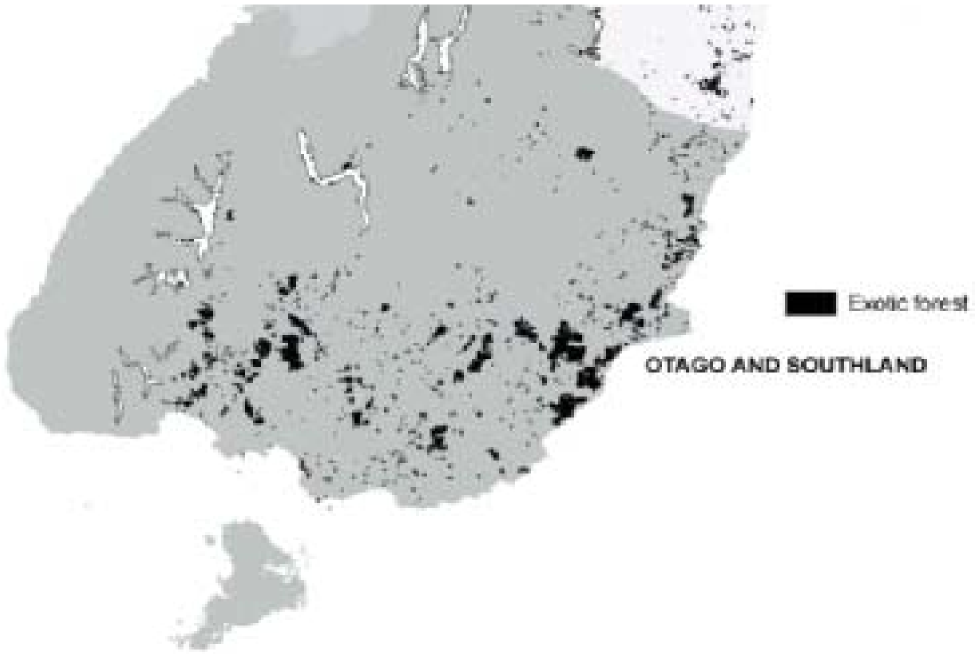


Figure A9.1 Forest Areas in Southland Source MAF

Forest and wood processing residues are produced as by-products of conventional forestry and wood processing.

Cutover remains on the forest floor where cut or trimmed. Forest residues are produced at the landing with whole tree harvesting and can then be prepared and loaded for transport. A range of preparation and transport arrangements are possible.

Various management regimes are possible for short rotation tree crops. Short rotation woody crops grown intensively under a coppice regime are a means of sustaining biomass supply. Tree crops can also be grown in association with land-based wastewater treatment, the trees taking up nutrients in the course of treating the effluent. There has been some research into species selection and breeding programmes, and into hydraulic loading rates of effluent on to various energy crops and soil types.

Wood residues and woodchips (or wood comminuted into smaller chunks) can be mechanically fed into suitable heating plant. The resultant heat can be used directly or to raise steam for process needs or for electricity production via a steam turbine. The mechanical handling and burning of wood is a proven technology.

Harvesting systems, particularly for short rotation plantations have been developed overseas and some plant is in operation within New Zealand.

Considerable interest is developing in the potential for land disposal of effluent/sludge on to tree crops as a form of treatment. Further research is required but it is possible large areas of land will in future be used for energy crop production in association with effluent/sludge disposal.

Energy Extraction

There are three stages in the extraction of energy from biomass resources:

- crop production and biomass harvest or recovery;
- transport, storage, treatment (e.g. additional drying), and
- end use.

The conversion process to provide heat and electricity is commercially viable, there being many examples in the New Zealand wood processing industry. In the future it should be commercially feasible to directly turn the biomass fuel into a gaseous form prior to combustion (this is not the same as biogas from digestion). This approach would expand the use that can be made of dry fuel biomass, making it suitable for internal combustion engines, gas turbines, or a range of new and emerging technologies. This gasification avenue promises increased conversion efficiency, reduced emissions and better cost effectiveness.

Direct combustion of wood processing residues in 2-20 MWth boilers or furnace systems is a common form of conversion in the forest processing industry producing steam, hot water, hot gases or hot air. Where surplus heat is available, electricity production may be feasible for use on site or for export to the grid.

Independent heat and electricity generating utility companies could produce electricity and/or process heat for sale, based on wood-fired technology. Installations ranging from 10 MW to 30 MW electric output appear to provide adequate economies of scale. The fuel source could be cutover, arisings, residues, tree crops or mixtures of all four. However such heat plant would need to be 30-90 MW thermal and such plant consume a large quantity of fuel each day.

On a smaller scale, biomass in the form of “firewood” is a significant domestic fuel used for space heating, water heating and cooking.

For combustion of biomass in the non wood processing sectors such as education or health the biomass can be processed into pellets for ease of transport and on-site handling.

Techniques for drying, handling and storage of the material have been developed for a number of local applications. Wider development will occur once the relative economics improve.

A diverse range of technologies exists to convert woody biomass to useful energy, including combustion, gasification, pyrolysis and hydrolysis/fermentation systems.

Combustion
Combustion processes for heat applications consume most of the biomass for energy in New Zealand. Almost 80 percent is used within the industrial sector, particularly by pulp and paper plants and sawmills. Although combustion is a mature technology, refinements continue relating to emissions control and efficiency. Biomass combustion systems are available for a wide range of applications and systems with improved efficiencies and are increasingly able to handle fuel with higher moisture contents. Fluidised bed combustion plants are in common use in Europe.

Gasification
Gasification technologies have reached the commercial evaluation phase with several plants overseas undergoing detailed evaluation and monitoring. Gasification, as a technology has been proven for coal applications (though is still not widespread) and is currently being adapted for biomass. The gas produced (“syngas”) in a gasification plant is a mixture of carbon monoxide and hydrogen, with a low to medium heating value. Gas cleaning issues (particularly related to silica content) are now being addressed in MW-scale demonstration plant. The technology is progressing rapidly to full large-scale commercial uptake, and is expected to take a dominant position as the means of large-scale energy conversion over the period covered by this report.

Interest is currently growing in the use of biomass gasification products to produce Fischer-Tropsch liquids (FTLs). These liquids may eventually be produced at similar prices to petroleum-based diesel. FTL formulations tend to be cleaner burning than petroleum-based diesel.

Pyrolysis
Pyrolysis processes provide greater flexibility and higher conversion efficiencies compared to combustion, but capital costs are also currently excessive and technology is in the early stages of development. The product, pyrolysis oil, can be easily transported and thus separates the resource location from the site of use.

Advances in the hydrolysis/fermentation of ligno-cellulose to produce ethanol/methanol and lignin are promising with future cost reductions claimed. The alcohol fuels can be used in present designs of internal combustion engines, new micro-turbines, or as a source of hydrogen for fuel cells.

Cogeneration of heat and electricity is particularly efficient where there is a demand for the heat. New Zealand has several successful examples. However development of future plants will be limited by the current price and structure of the energy market, unless investment costs improve for embedded or distributed generation opportunities.

Co-firing of biomass with coal presents an effective means of displacing a portion of fossil fuels at minimal cost for heat generation. The co-firing of coal or gas in a biomass plant is likely to be attractive as it is used as a risk minimisation strategy to overcome short-term shortages of biofuel or, if part of the fuel specification, can allow significant capital and operating cost reductions.

Barriers

A difficulty with woody biomass has been the inconsistency of fuel quality. As a waste stream it can have a range of particle size, moisture content and other characteristics. This variability adds significantly to the costs of handling. The economics of bioenergy are significantly increased if a woody biomass fuel can be standardised.

As the future use of forest residues and other wood wastes as material input to further manufacture become more important competition for the resource between production and energy end uses could become one of the many potential factors limiting the use of wood waste as an energy source. Already bark is being used as a raw material for garden products. It is believed that as sawdust is generally a homogenous product it will take on greater value as a feedstock for manufacture. Wood waste remaining for use as an energy fuel is likely to be limited to the scrap from harvesting and processing.

Fuelwood crops could be grown close to heat and electricity demand centres, reducing transport cost and transmission losses. Where wood drying at source is viable this may reduce transport costs or increase the fuel catchment area. Generally crops could be harvested all year round, although wet ground conditions may be a restriction at some times. In any event the wood can be stored until needed. However the opportunity value of the land is such that this is unlikely to be economic for some years.

Economics

The bioenergy cost ($/GJ of useful energy output) is particularly sensitive to:
- fuel feedstock production costs
- harvesting costs

- moisture content
- fuel quality (including contamination issues)
- transport distance
- capital cost of equipment (especially fuel handling equipment)
- labour requirements
- conversion efficiencies, and
- load characteristics.

Input feedstock costs range from a negative cost for disposal of wastes, through $20-30/tonne for residues used on site, to $40/tonne for processed biomass transported some distance to the point of use. Green biomass has a relatively low energy content (7-10 MJ/kg), which gives problems of transport, storage and handling and hence increased costs/GJ. Often biomass is difficult to recover, is poorly distributed, and is produced some distance from the markets. The exceptions are wood processing residues used on site and energy plantations grown near to areas of demand.

Currently only process residue is considered to be competitive with coal for industrial heating as shown in figure A9.2. Biomass forest residue material is too expensive mainly because of transport costs. However with greater experience of waste collection and processing it is expected that forest residue costs will decrease and the economics will thus improve.

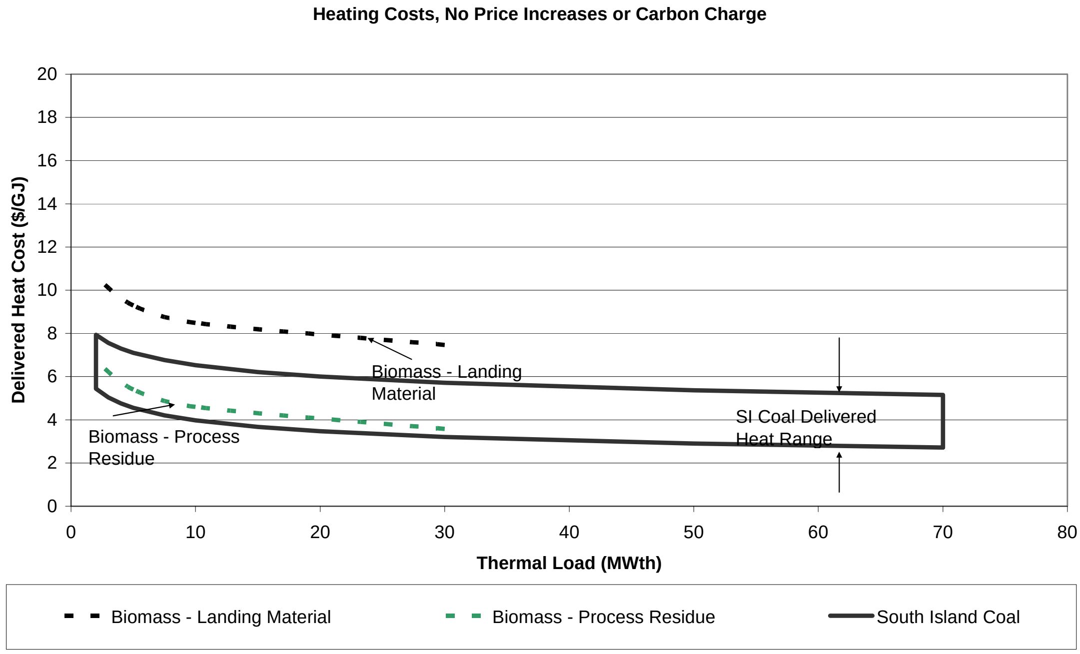


Figure A9.2 Heating Cost from Various fuel types

With the rundown of Maui gas and replacement with more expensive new gas it is expected that national coal prices will rise as well. This rise will be limited to maintain coal's market share. In 2008 the carbon tax will add to gas and coal costs, adding more to coal than gas. Biomass will not be affected by the carbon tax. Overall heating costs assuming increases in national energy costs and the introduction of a carbon charge in 2007 are shown in the figure A9.3.

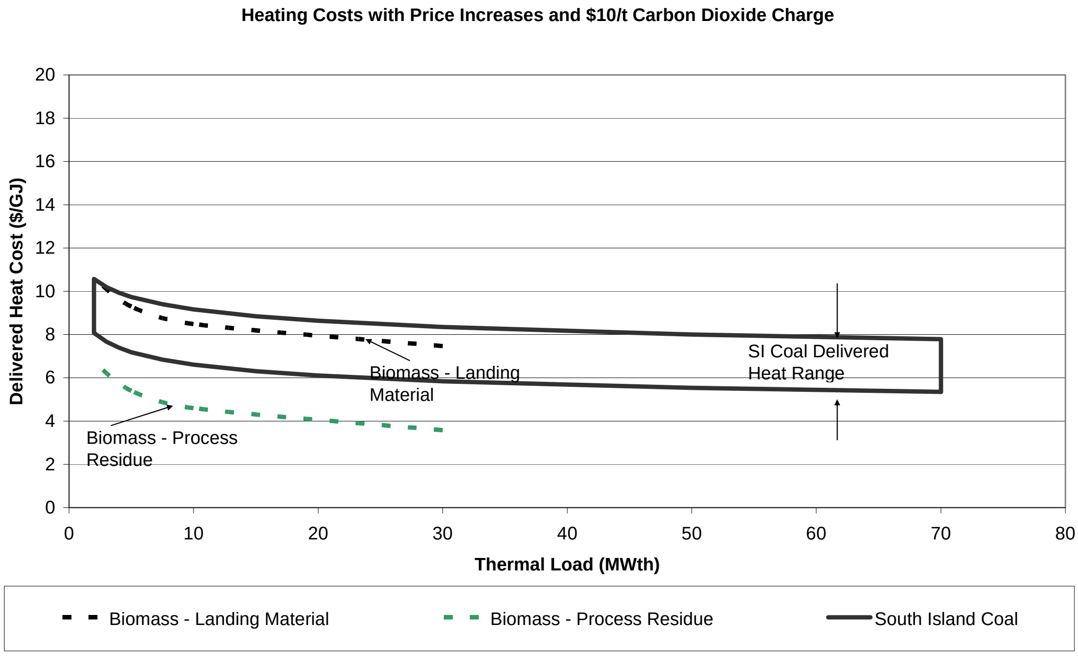


Figure A9.3 Industrial Heating Costs Assuming Gas Price Increases and Introduction of a Carbon Charge

Post 2007 heating using biomass process residue will have an economic advantage over coal but biomass landing material will be just competitive with coal in some locations.

The economics of large scale generation of electricity from bioenergy are such that while currently uneconomic, post 2007 with the introduction of a carbon charge under the Climate Change policy electricity generation from bioenergy will begin to become economic. The economics will commence with investment in cogeneration facilities; and then embedded electricity production; leading to larger scale electricity production post 2010.

Electricity production from a 40MWe bioenergy facility is assumed to at 9 - 15c/kWh (dependent on the cost of fuel). However such a sized facility would require 850 to 2300 tonnes of wood waste each day which would be difficult to achieve in Southland. Such a facility would also need to be built near a 110kV transmission line in order to reduce transmission costs.

It is estimated that for a sawmill processing 250 m^3/day of logs, 160tonne/day of woody biomass waste could be available as a fuel. The mix of fuel source is;

Green sawdust	10%w/w as received logs
Bark	5% w/w as received logs
Slab wood to hogged fuel	30% w/w as received logs
Dry shavings	14 t/day

Based on this quantity of wood waste available it appears that a 10 MW_{th} boiler could be utilised. Feeding all the steam into a 2.6 MW_e second hand steam turbine generator would result in electricity being produced at a cost of 9-11c/kWh. To produce more electricity than this would require fuel to be brought in which would be at a cost and thus would increase the cost of electricity produced by about 5c/kWh. Use of a new steam turbine generator would increase the cost of electricity very significantly.

The most likely sized bioenergy facilities are likely to be plant of around 2-3 MW_e embedded into a wood processor site. With the probable shortage of on-site wood waste it is likely that the biomass will have to be supplemented by coal / lignite or forest residue. The cost of electricity would rise if this was the case to around 14-16 c/kWh because of the increased cost of the supplementary fuel.

For the same plant using wood pellets with the current price of $600/t discounted by 75%, the cost of electricity is 35 c/kWh. At this price there is likely to be minimal uptake of this fuel.

Environmental

In carbon accounting, biomass is assessed as being fully converted to CO_2 at the time of harvesting for Kyoto (post 1990) forests. Where biomass developments are sustainable (as they would be for any managed plantation forest), any combustion of waste biomass is counted as making a zero contribution to CO_2 emission, qualified by the small amount of fuel used in harvesting, comminution and transport.

Uptake of forest wood waste products has not been high, with almost no use of cutover and arisings, and only partial use of wood processing residues. In most cases wood is left on the ground to decay. In the case of wood processing residues, there can be a cost associated with simple combustion or landfilling (with subsequent methane emissions).

There has been significant new planting in recent years. This will both increase the availability of a potential fuel, and increase the need for disposal of the waste product.

Burning firewood in domestic burners can be an efficient resource use compared with power generation from the same biofuel, and can be clean burning if properly designed.

Appendix 10

Gas

A10.1 On shore Gas Fields

There is extensive onshore gas fields in west Southland that are reputed to be similar in size to some Taranaki fields (such as McKee) to which it was directly aligned prior to separation by strike-slip motion on the Alpine Fault.

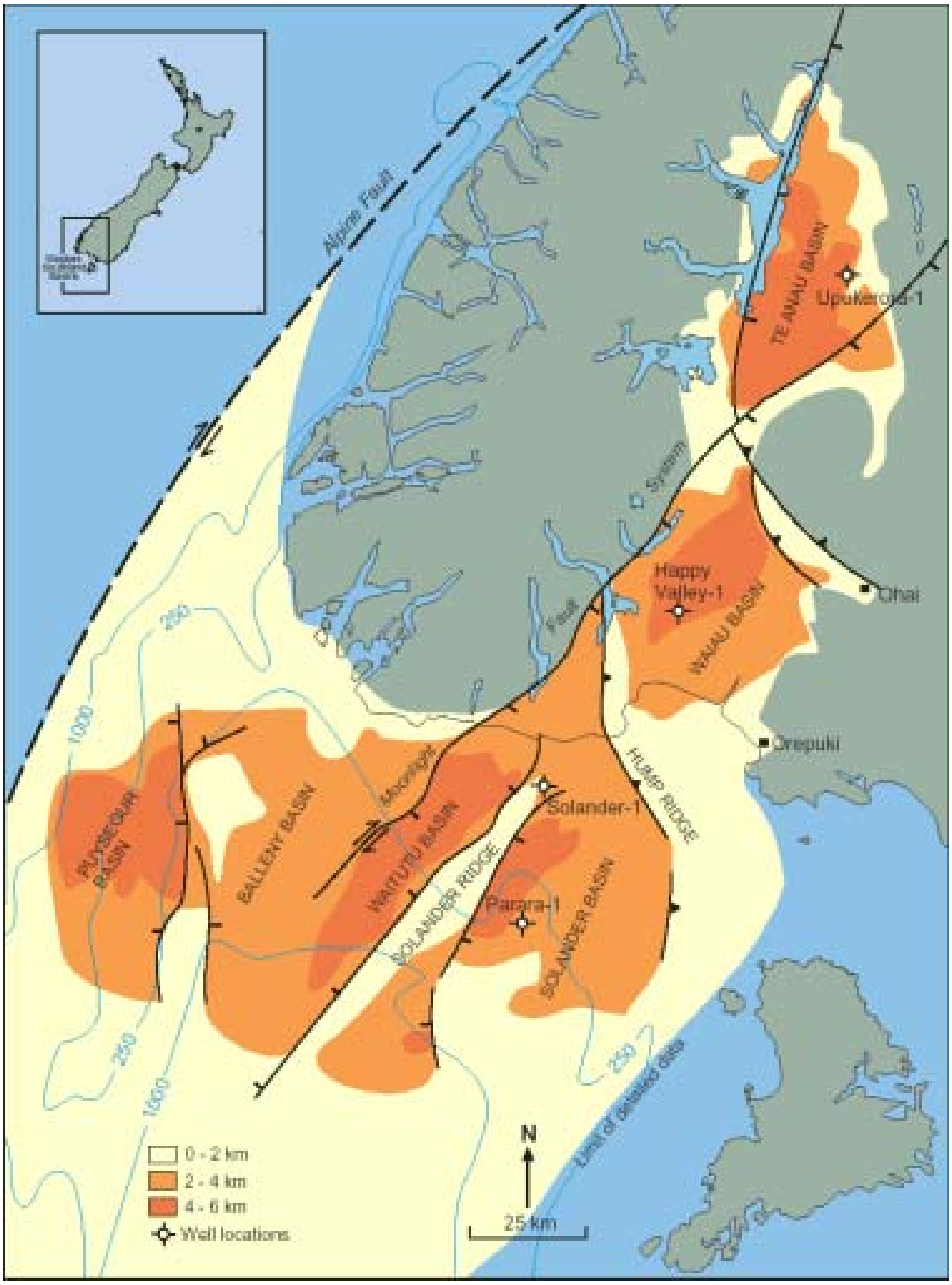
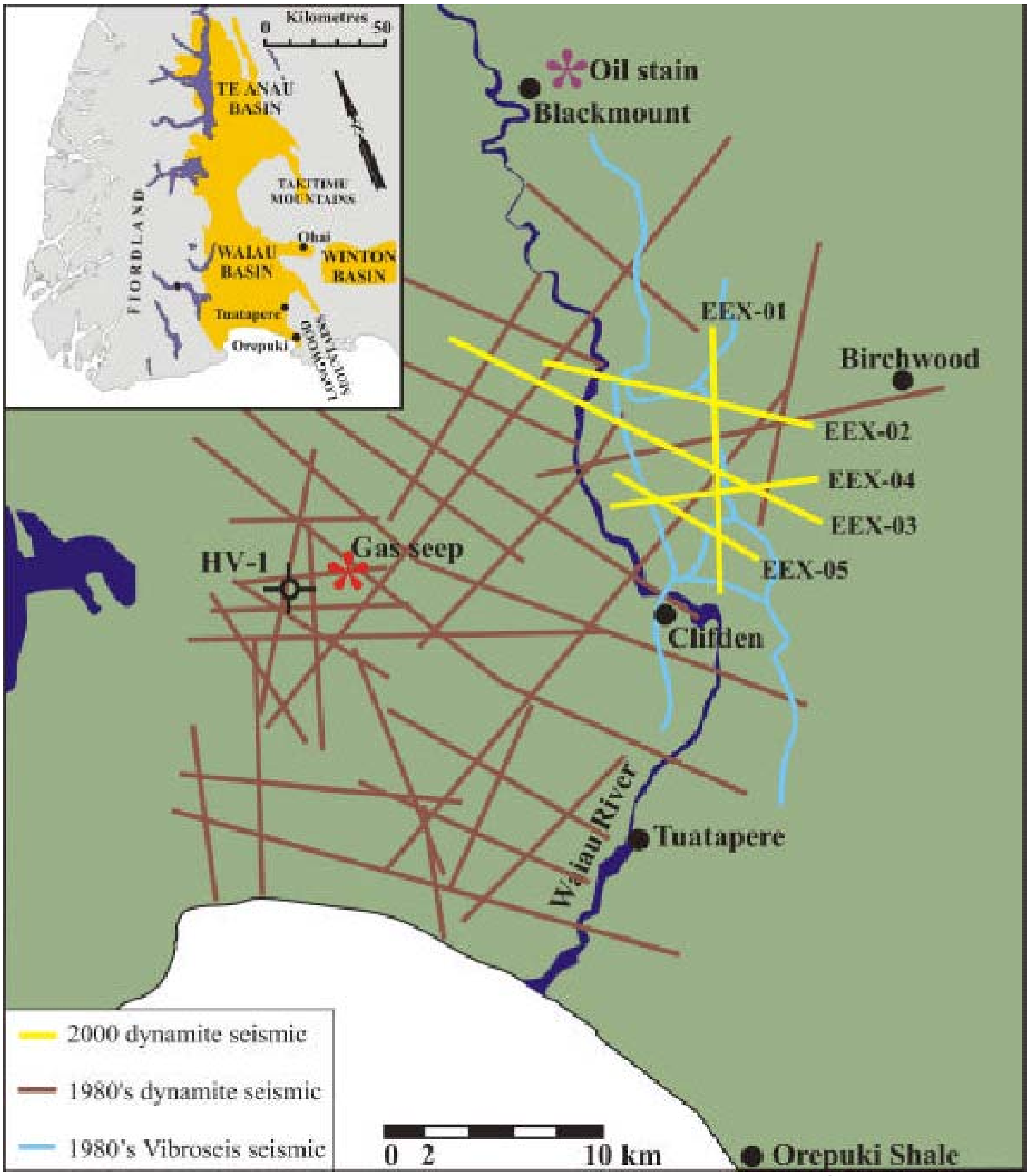


Figure 10.1 Source MED

The area has had a history of exploration for the past 100 years and the western Southland region has long been regarded as being hydrocarbon prospective. Four shallow wells were drilled in the eastern Waiau Basin from 1955 to 1958. In 1987 and 1988, Petrocorp drilled Happy Valley-1 to a depth of 3270 m in the central Waiau Basin and Upukerora-1 to a depth of 2009 m in the eastern Te Anau Basin. No hydrocarbon shows were reported and both wells were plugged and abandoned. However none of these wells fully tested the potential of their respective basins over the region as a whole, but their failure to produce hydrocarbons saw further exploration largely abandoned until the late 1990s.

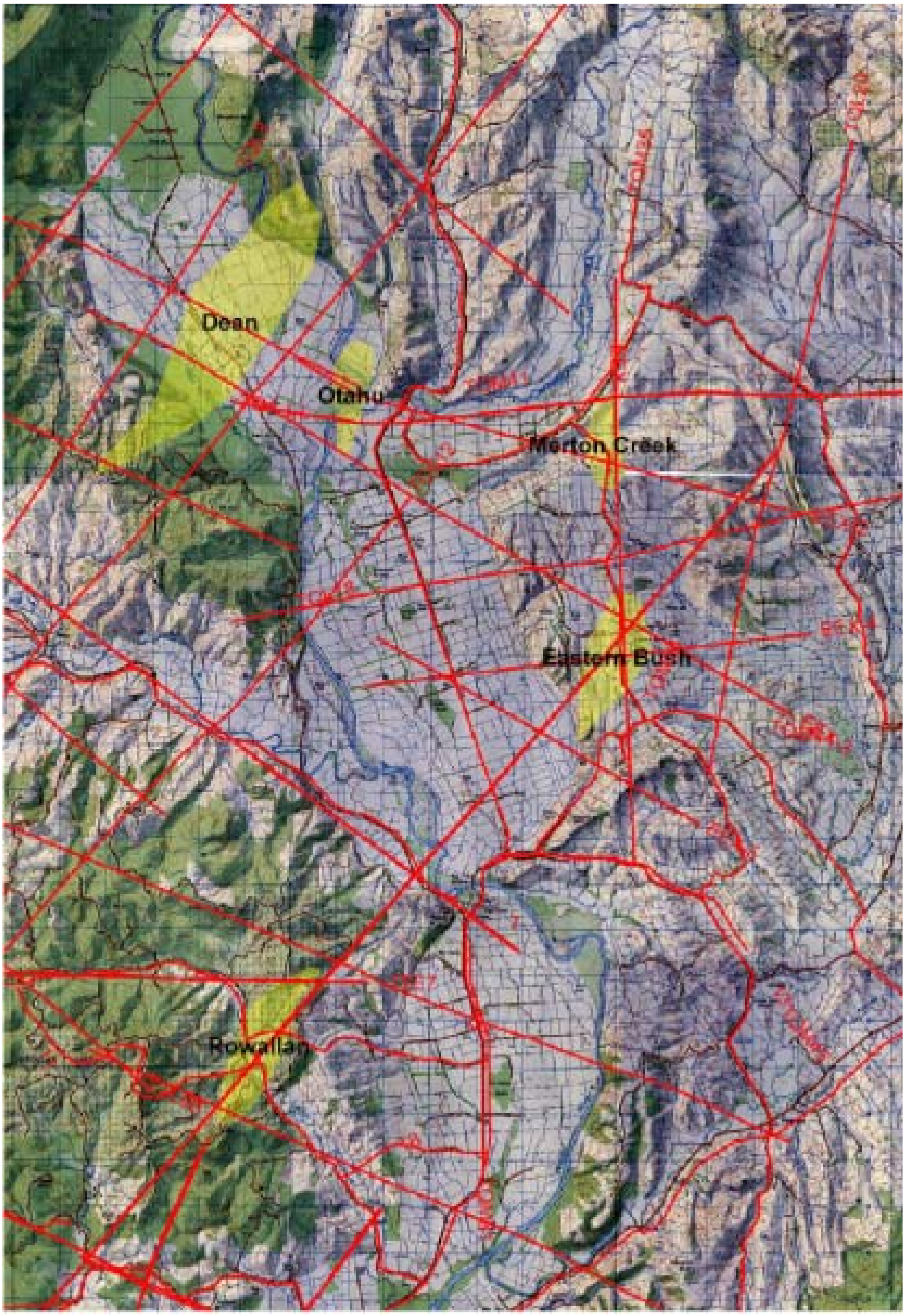
The map in figure A10.2 shows the location of seismic lines within the Waiau Basin.



Source: Geosphere

Figure A10.2 Seismic Lines in the Waiau Basin

Seismic data that exists over the central and eastern parts of the Waiau Basin, and the prospects and leads that have been identified from regional seismic mapping are shown in figure A10.3.



Source: Geosphere

Figure A10.3 West Southland Field Locations

Onshore the Eastern Bush Prospect is one of several prospects and leads identified within the Waiau Basin. Recoverable oil reserves are estimated to be between 2.9 and 158 mmbbls, with a mid-range case of over 50 mmbbls. A similar quantity of gas is likely to be present.

GeoSphere Exploration and Thomasson International Ventures hold permit PEP 38223 over part of the Te Anau Basin on the eastern side of Lake Te Anau, as well as most of the Waiau Basin to near the south coast. The joint partners plan to drill the Eastern bush prospect in the Waiau Basin but are seeking further partners before they proceed. A tentative budget for a further exploration well is $3million.

A10.2 Offshore Gas Fields

South West Southland

Two offshore wells have been drilled in the Solander Basin. Parara-1 was drilled to a depth of 3803 m in 1975-76 and encountered oil staining in Late Eocene sandstones. In 1985, Solander-1 was drilled to 2017 m with no significant shows. The Balleny and Waitutu basins have yet to be drilled.

Great South Basin

The presence of hydrocarbons in half the exploration wells drilled, the large thick sediments, and the large number of potential leads make the Great South Basin one of New Zealand's most prospective for both oil and gas.

The Great South Basin is the largest of several that lie on the Campbell plateau to the east and south of Southland. Initial basin formation was similar to that of most New Zealand basins, with rifting and deposition of thick coal measures during the late cretaceous, but the Great South Basin differs in having had little deformation since.

Petroleum exploration began in 1969 when Hunt International Petroleum Company obtained a licence covering much of the Campbell Plateau, and acquired over 30,000 km of seismic reflection data over the basin. Hydrocarbons were found in four of eight wells Hunt drilled between 1976 and 1984. Kawau-1A tested gas with some condensate up to 6.8 mmcf/d. Reserves were estimated as 461 bcf gas but were sub-commercial in view of the water depth and remoteness. Toroa-1 could not be tested because of technical problems with the well.

The petroleum potential of the large offshore basin has attracted three Australian based companies while Bounty Oil and Gas hold a permit over the middle of the basin.

A 10.3 The Value of Gas

Gas is the most valuable energy resource that Southland has. As an energy source gas is flexible, is safe, can be stored and is a easily used fuel. If the gas under Southland can be brought to the surface at an appropriate price then it could be used to firm the renewable energy that is currently and potentially used. While gas is a premium energy source for the region, it is the oil that exploration companies normally seek because it is internationally more valuable.

The highest priority activity that the region could do would be to encourage further exploration of the Southland gas fields.

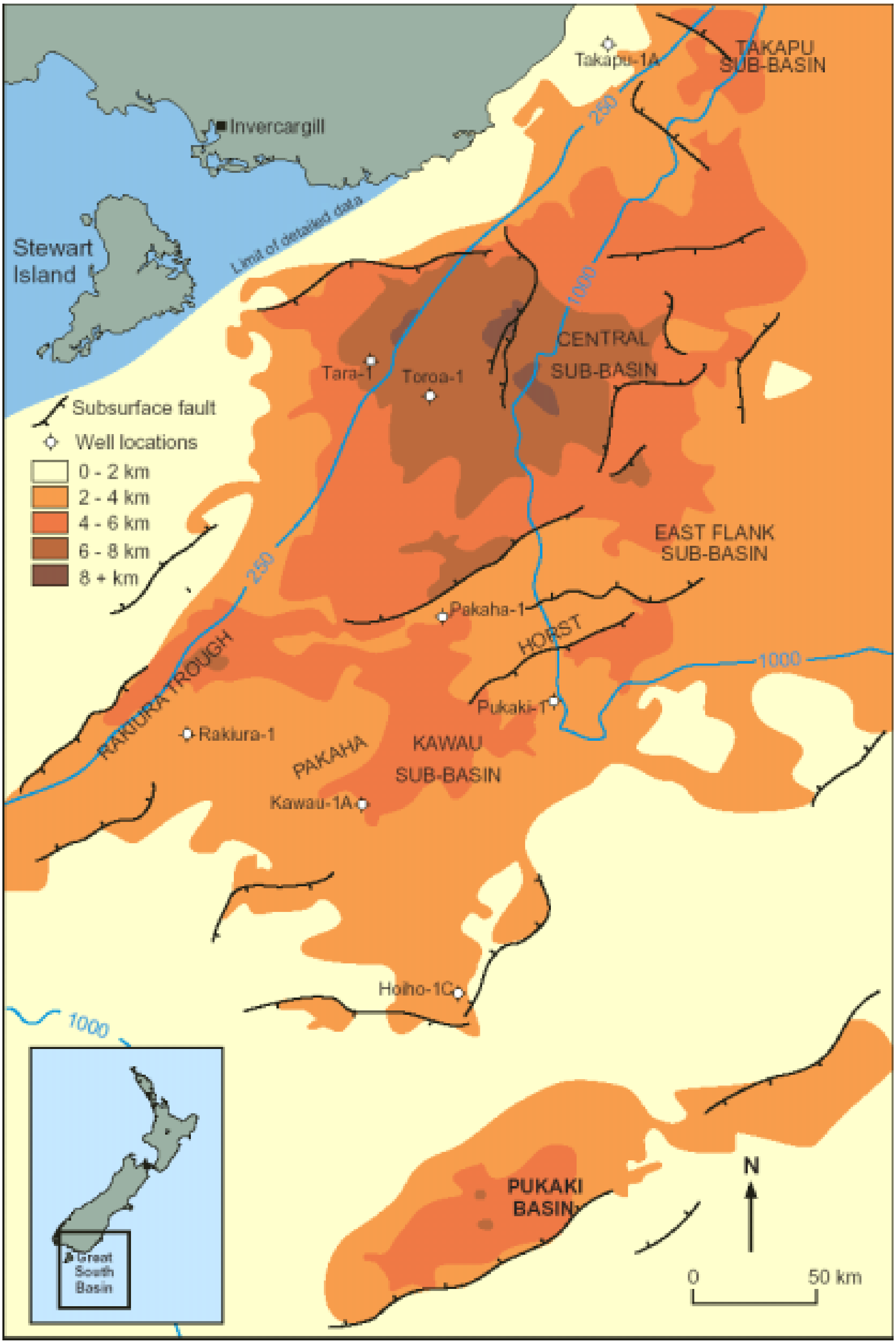


Figure 10.4 Source MED

Appendix 11

Biogas

11.1 Anaerobic Digestion

Biogas is commonly produced by anaerobic digestion as part of the treatment of wet organic waste. This occurs in municipal wastewater and sewage treatment plants, industrial operations that have liquid wastes containing organic material, and on types of farms where animals are kept or held in a small area, such as pig or poultry farms.

In many cases treatment of the waste to produce biogas is not economical in itself but is carried out for other reasons such as waste management, or reduction in greenhouse gas emission initiatives. Also small scale generation of biogas is rarely economic because of the high labour requirements and dilute nature of the effluent being treated.

Anaerobic digestion is the decomposition of organic matter in the absence of air to produce biogas. The biogas is a mixture of mainly methane and carbon dioxide with very small amounts of hydrogen sulphide and other impurities. The methane content can range from 50% to 80% (on a volumetric basis).

Biogas from the digestion of crop materials is typically 55% methane and from animal manures typically 65% methane.

Biogas from meat and poultry processing effluents and sewage plants tend to have higher levels of hydrogen sulphide (H_2S), up to 5%. Biogas with these amounts of H_2S may require further treatment before use.

The high amounts of carbon dioxide in biogas typically reduce the heating value to between 18 and 26 MJ/m^3 (GCV) compared with natural gas typically around 40 MJ/m^3 (GCV).

Unless biogas demand meets biogas production, storage may be needed or the biogas flared or vented. Low pressure storage can be in gasometers or butyl rubber bags.

Biogas from anaerobic digestion can be used to produce heat for the digestion process itself, or process heat and electricity in other parts of the plant. It can also be upgraded to “natural gas” quality and fed into a local utility network.

The biogas can be used as a fuel in a number of different types of plant such as reciprocating gas engines, mini-gas turbines, Stirling engines, and fuel cells or by direct combustion in boilers or other CHP heat plant.

Anaerobic digestion is a mature technology and is used worldwide, particularly for municipal waste water treatment. Here the scale of treatment can justify the costs of installing and operating the equipment needed. If the organic content of wet waste stream is too dilute, recovery of the energy content will be made more expensive.

Biogas from anaerobic digestion is essentially a continuous process so it requires a reliable continuous feed of material.

Waste effluent is generally very dilute so processing this is difficult and expensive. Excess moisture may cause handling problems for gasification processes.

The main synergy for biogas is between waste management and environmental controls.

There are significant environmental benefits from waste digestion. These include reduced impacts of the effluents and solid waste disposal. Sludge from the digesters can be returned to the soil as fertiliser.

Production, collection and use of biogas reduce methane emissions to the atmosphere. Methane as a greenhouse gas has 21 more times greater effect than carbon dioxide. Hence, using biogas from a sustainable source is nearly carbon neutral. The energy from biogas will replace energy from other sources which may have come from non-renewable fossil based sources.

Processing solid waste through a gasifier reduces the bulk of material going to landfill sites, controls use of carbon based material in the waste, and reduces hazardous materials going to waste sites.

11.2 Dairy Farm Biogas

At 30 June 2002 Southland had 356,000 head of dairy cattle from 610 farms. It is estimated that a 445 herd dairy farm would produce 71 kg of volatile solids per day and a 350 herd farm produce 56 kg of volatile solids per day.

The potential energy available from processing the manure in an anaerobic digestor is relatively low however the collection and treatment in a digester of 71 kg of volatile solids per day would produce 28 m^3 of methane per day. The gas could be used to heat water at around 2.5c/kWh.

This methane would be able to be converted to 74 kWh of electricity if used as a fuel in a diesel engine. The estimated cost of electricity generated by a 20kW biogas unit is 17 c/kWh.

If 5% of the manure from all the farms was collected and processed the total amount of energy could be approximately 5 GWH pa in the period up to 2010 and 20 GWh pa by 2015.

In practice only a small fraction of the farms would install the plants for energy reasons alone. There would however be environmental benefits from processing the waste which may offset some of the cost and biogas production should be considered as an environmental solution for waste disposal.

11.3 Agricultural Residues and Crops

Residue from agricultural crops can be a good source of energy as was shown by the use of husks in the Gore Flemings factory before it closed. However growing agricultural crops as a purpose grown energy source is uneconomic in New Zealand and that is unlikely to change in the next two decades.

There are no known agricultural residues currently available in Southland so the use of agricultural crops is not considered further in this assessment.

11.4 Municipal Solid Waste/Sewage Treatment/Waste Water Treatment

The new landfill being developed in Southland provides an opportunity for the production of energy by the collection of the landfill gas. This would have to be considered at the design stage so that the facility can be constructed for the efficient collection of gas. While similar facilities are located in all major centres in New Zealand some have not been successful, generally because of gas collection problems.

Electricity produced from the landfill gas would cost from 5 to 9 c/kWh.

Analysis of Southland waste indicates that 55% of the waste consists of organic waste which could be used for energy production. Introducing a system of source segregation of waste can result in significantly reduced landfill waste volumes and can reduce the cost processing of organic waste into energy .

Rapid prolysis may be a useful technology as it destroys practically everything with very minimal emissions.

A typical system suitable for Southland has recently been built in Sydney. An Invercargill facility of 10,000tpa could produce around 6 GWh per year of energy plus a substantial amount of fertiliser/compost..
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11.5 Industrial Waste

There are several industrial sites within Southland such as the Edendale Dairy factory where disposal of industrial liquid waste is by spray irrigation. As the soil receiving capacity becomes limited there may be opportunities for the processing of this waste in bio-digesters to produce energy. These require further and more detailed investigation on a case-by-case basis.

In a typical meat processing plant the digestion of liquid waste can produce around 0.6 MW of electricity at a cost of around 7c/kWh.

Appendix 12

Transport Biofuels

12.1 Government Policy

As part of the National Energy Efficiency and Conservation Strategy, a target has been set for an additional 30 Petajoules (PJ) of consumer energy from renewable energy sources by 2012. With over 99% of transport energy currently coming from non-renewable sources, a 2 PJ indicative subtarget has been set for the transport sector in order to signal the longer-term pathway required. This indicative renewable energy target for transport is equivalent to 1.2% of the petrol and diesel used in road transport.

Potential New Zealand sources of renewable transport fuels are ethanol from whey, a dairy processing by-product (0.3 PJ per year), sugar beet, and biodiesel from tallow, a meat processing by-product (4 PJ per year) or used cooking oil. Together these indigenous biofuels have the potential to provide 185% of the renewables target for transport in the near term.

Some biofuel blends with petrol or diesel could be sold through the existing retail network, with no modifications to vehicles in the national fleet required. Examples of blends which can be used without engine modifications include up to 10% ethanol in petrol (E10), or 6% biodiesel in diesel (B6). Neat (100%) biodiesel can also be used without engine modifications, but is best used in captive diesel fleets where some engine modifications ensure full performance is retained when using biodiesel.

Initial work suggests that renewable fuels from these indigenous by-product sources are close to economic. Companies interested in introducing biofuel blends have recently approached EECA. International sources of biofuels are being investigated further, in particular bio-ethanol from Australia and Brazil.

A new EECA work stream in biofuels is incorporated in the draft Energy Efficient Motor Vehicle Strategy to assist the early commercialisation of biofuel blends, through the removal of regulatory barriers, and partnerships with the transport fuels industry and motor vehicle industry, in particular to provide consumer information.

EECA currently has an application to the Environmental Risk Management Authority (ERMA) to allow the import and manufacture of blends of up to 10% ethanol in petrol under the Hazardous Substances and New Organisms Act.

12.1 Ethanol (Sugar Beet)

Bio-ethanol is probably the most cost-effective renewable transport fuel, and as such the Energy Efficiency and Conservation Authority (EECA) recently commissioned a study into the implications of its introduction to New Zealand.

Ethanol for transport fuels is most commonly produced from sugar crops by fermentation and distillation. The most effective crops that can be used to produce ethanol in New Zealand are maize and sugar beet. Ethanol can also be produced from woody biomass but at a significantly greater cost.

Generally blends of up to 10 percent ethanol in petrol (E10) can be used in modern vehicles without any appreciable changes in performance. Studies in the 1980s identified that there is potential to produce enough maize and sugar beet to replace all petrol in New Zealand with an E10 blend many times over, although this would require substantial changes to farming patterns. Adding 10 percent of pure ethanol to all petrol used in New Zealand (204 million litres) would require 40,000 to 45,000 hectares of land planted in sugar beet.

Early New Zealand studies have shown that sugar beet would be more than competitive with alternative crops that could be grown in Southland area. It appeared that ethanol could be produced at a competitive price from sugar beet priced at a level that would give a good return to the grower. The cost of ethanol produced in New Zealand from agricultural crops, is currently estimated to be 55 to 80 cents per litre tending towards the higher end of the range.

On the other hand there is an opportunity cost compared with alternative land uses. For example, there is a higher opportunity cost of land in dairying compared to sugar beet or maize for energy cropping.

The conclusion is that the relative price of petroleum fuels compared to biofuels would have to rise by at least 50 - 100% in order for biofuels to be competitive. Further work would be required to confirm this.

12.2 Ethanol (Whey)

In New Zealand ethanol has been produced for a number of years from whey, a by-product in the dairy industry. Annual production is about 18 million litres which is targeted at the higher end of the export market.

12.3 Biodiesel

Biodiesel is a renewable fuel made from animal and vegetable fats and oils. The raw materials can come from virgin or waste products.

Biodiesel can be used as a straight fuel or blended with petroleum diesel. Most biodiesel is sold as a blend. Blends up to about 20% biodiesel do not require current diesel engine modification. Above this level modifications are required.

Biodiesel is being made commercially in Europe, and the USA, and a biodiesel plant is being constructed in Australia. There is a widespread cottage industry of enthusiasts making biodiesel.

In France it is mandatory for 50% of transport fuel to have a renewable fuel component. The effect has been that all diesel sold there is a blend of 5% biodiesel.

There is an extensive network of biodiesel refuelling stations throughout Germany with some German car manufacturers (principally Audi and Volkswagen) producing cars that run on 100% biodiesel.

Costs of biodiesel are generally considerably higher than petrodiesel. Newer processes are reducing the costs significantly. The Biox process developed in Canada has reduced the production costs from US$.25 to $.3/l to US$.08/l. (Capital cost not known). Use of waste fats and oils also reduces the price significantly.

It is estimated that biodiesel could be produced in New Zealand at a cost of $31/GJ or $0.7/l.

Appendix 13

Future Technologies

A13.1 Wave, Tidal and Ocean Currents

Wave Power

Wave power results from the harnessing of energy transmitted to waves by winds moving across the ocean surface. It is best suited to small-to medium-scale generation, either on-shore or off-shore. Local coastal topography and the availability of natural shoreline formation limit the size of the on-shore plants.

New Zealand has potential for a number of plants with power output of up to 3MW. One of the technically most robust systems is to use natural features such as coves for on-shore systems by damming with multiple tapered channel structures.

Transmission by submarine cable is a significant capital cost component for offshore systems.

There are a number of different wave generation technologies. The generic technologies are:

- Tapered channel/ reservoir systems: uses traditional tidal or hydro turbine generation plant.
- Oscillating column systems: uses air pressure generated by wave movement to drive turbines.
- Reciprocating mechanised systems: uses flotation devices to drive piston, pumps etc.
- Piezoelectric systems.

As the depth of the water decreases, waves lose energy, therefore there is more potential energy to be obtained from off-shore than from on-shore or near-shore power plants. The most successful plants so far have been tapered channel or other such near-or on-shore devices.

Large off-shore installation is limited by major infrastructure issues, like requiring substantial investment in undersea cables and land transmission lines. Tampered channel systems are also limited in capacity by the available wave height.

Small demonstration plants are currently being trialled in several places around the world with projected electricity prices from commercial sized plant being in the range 6 to 20 c/kWh.

Tidal Power

Tidal generation plants are capital intensive as they are designed to handle relatively large volumes of water over short periods.

A number of novel technologies exist in order to reduce the high capital costs of the plant. Tidal barrages are the proven tidal power systems that use the traditional hydroelectric storage method.

Since the tidal movements are produced by the interaction of the moon and sun, they can be predicted with great accuracy. The plant cannot take advantage of economically advantageous peak demand periods because the direction of the tides changes every 12 hours 25 minutes and the power generation will not always be synchronised with a daily power demand curve.

The biggest obstacle in the development of the tidal power system is the relatively high capital cost for low utilization. Tidal power stations can only be built where there are large tidal flows, maximum high/low tidal ranges and where natural submarine features allow construction at lowest costs.

Ocean Current Power

Ocean current generation is based upon plant, similar to wind turbines. To produce small to medium GWh outputs grouping of a number of small turbines would be required. This can be compared to a wind farm layout set at ocean floor. However due to the lower current speeds and denser fluid, the distance between the turbines are likely to be less than the wind turbines.

The cost of electricity from a 20 turbine, 6 MW project in Norway is estimated to be 10c/kWh when completed in 2004. This is three times the cost of hydro power in Norway.

The ocean current resources, similar to the tidal streams will have a cyclical period and velocity variation. However, due to the application of different technologies and scale of plant, the variation produced by the ocean current resources will be less limiting than tidal head in terms of generation efficiencies.

A13.2 Coal Bed Methane

Methane, carbon dioxide and water are generated as by-products of the coal formation process. The proportions of each gas produced vary during the process. Most of the gas and water migrates away from the coal seam. However some gas is retained within the coal seam. Generally the higher the coal rank the higher the gas content.

Several different techniques are used to drain methane from coal seams. Within coal mines methane is drained ahead of the mining by drilling holes along the coal seams ahead of the mining. Boreholes from the surface are also drilled into the mined out areas to drain methane from collapsed areas.

These methods of pre-drainage and post-drainage have only been partially successful in controlling the gas inflow into mines. Significant improvements in gas drainage are required.

Increases in coal production and the attendant increases in the depth of mining results in even greater levels of methane. Surface pre-drainage techniques can provide a solution to mining problems and also provide a method of recovering the methane by itself for commercial uses.

Fracturing the coal seams with hydraulic pressure within boreholes (hydraulic fracture stimulation) may represent the method of highest potential for the development of a methane drainage industry.

Interest in coal bed methane is current. Christchurch-based Kenham Holdings Ltd, an associate of South Island alluvial gold mining company L&M Mining Ltd, has been awarded four new petroleum exploration permits for coalbed methane gas. These are a 173 sq km permit (PEP 38221) over a lignite field in Southland between Edendale and Invercargill, a 540 sq km permit (PEP 38515) over the Stockton plateau near Westport, a 344 sq km permit (PEP 38611) near Meremere in north Waikato, and a 125 sq km area (PEP 38610) over the Kamo coalfield on the northern outskirts of Whangarei.
Source: NZ Petroleum News, April 2003

Technology New Zealand is providing investment support for a project to develop new technologies that allow for the commercially viable extraction of methane gas from low-ranked coalfields. If successful, the systems could also be adapted for international use.

Kenham Holdings Ltd, an associate company of the long-established L & M Mining Ltd, and CRL Energy have been researching new processes to tap into the methane resources for about two years. A decision on the commercial viability of some areas under investigation is expected before the end of the year.

If successful, the methane extraction from low-ranked coal will provide a new energy source for New Zealand and deliver major environmental benefits. Previous studies indicate that there are potential gas deposits in the 8.5 billion tonnes of coal held under permit by Kenham Holdings. Mining the gas will also reduce the potential for methane to leak into the environment, thereby helping to contain global warming.

A13.3 Hydrogen

Over the next two decades, hydrogen produced from renewable sources of energy has the potential to offer "zero CO2 emission" vehicles for road transport. Fuel cells are seen as the most efficient way to turn hydrogen into motive power. However a long transition to hydrogen from hydrocarbons is likely.

International developments and pilots in hydrogen for use as a transport fuel are underway. Direct use of hydrogen in internal combustion engines may occur in the future, but fuel cells are still 50 times more expensive per kW than petrol or diesel engines and hydrogen storage issues are yet to be fully resolved. The International Energy Agency’s (IEA) view is that it will be well past 2012 before the hydrogen economy kicks in.

The Government has released its Energy Efficient Motor Vehicle Strategy in which it states that “international developments in the use of hydrogen vehicle technologies will be closely monitored to identify any appropriate opportunities to assist commercialisation in New Zealand, within a context of overall reduced CO2 emissions**.** This means that any CO2 emissions from energy used to manufacture, transport and store hydrogen for use as a transport fuel should be lower than the CO2 emissions associated with the manufacture, transport, storage and use of fuels that the hydrogen is replacing. Until it is clear that any additional electricity demand is coming from renewable energy sources, using electricity to produce hydrogen as a transport fuel is unlikely to result in an overall reduction of CO2 emissions. Other countries have come to similar conclusions, including a recent major report from the United Kingdom.

There is a slight risk that this somewhat cautious approach may result in vehicle technologies developed overseas being designed for energy sources for hydrogen which do not match New Zealand's optimal energy sources for hydrogen However, New Zealand is probably not a large enough market to influence the direction of overseas developments in hydrogen vehicles.

Becoming a member of the IEA Hydrogen Implementing Agreement, which has been in place for more than twenty years, may be one way to ensure that New Zealand is not left behind in the gradual change to a practical hydrogen economy for transport."

The facilitation of interim fuel efficient technologies, such as hybrid electric/ petrol vehicles, should not detract from a transition to a hydrogen fuel cell future. A "hybrid" vehicle has inherent energy efficient advantages which would also benefit, for example, a hydrogen fuel cell vehicle. These include regenerative braking, where the energy otherwise lost in braking is captured and stored for later use,

Methanol may be the best medium for storing hydrogen in the short term because it has a relatively high proportion of hydrogen by mass. Moreover, methanol is easier to handle than methane because it is a liquid. Pure molecular hydrogen would be the most energy-efficient fuel, but is extremely awkward to store in a car in its gaseous state.

Chemically bound hydrogen is found everywhere on Earth: in water, fossil fuels and all living things. It is rarely found as a gas in nature. Instead, it has to be extracted from water or from hydrocarbons.

Sources of Hydrogen

There are several possible sources for hydrogen:

- Electrolysis of water - Using electricity to split water molecules to create pure hydrogen and oxygen.
- Reforming fossil fuels. A reformer can split the hydrogen off the carbon in a hydrocarbon relatively easily and then use the hydrogen.
- The chemical or thermal reformation of biomass feedstocks such as SRC (short rotation coppice) wood chips or methanol manufactured from biomass.
- The biological reformation of biomass using micro-organisms.
- The direct splitting of water using light with special catalysts or extreme heat.

Hydrogen has some disadvantages that require considerable research and development:

- At present producing hydrogen requires more energy than can be obtained from it.
- Liquefying and compressing hydrogen requires 20-40% of the energy it produces, and pressurized storage tanks weigh many times more than their contents. Metal hydrides can store hydrogen at close to atmospheric pressure, but are too heavy for many uses.
- With widespread use leakage of hydrogen into the atmosphere will occur. Recent research suggests that this may cause problems by interfering with the earth's ozone layer.

A13.4 Fuel Cells

Fuel cells, ranging in size from 1 kWe to 10 MWe, are electrochemical energy conversion devices that use hydrogen and oxygen to produce electricity, heat, and water. The electrical production is relatively efficient when hydrogen fuel is used (40-60%) since there is no combustion or large moving parts involved and therefore less energy conversion to heat losses. Where a supply of hydrogen is not directly supplied it is necessary to have, in addition, a hydrocarbon fuel reformer. Also, fuel cells produce direct current and therefore require inverters to enable the output to be synchronised with the grid.

The recent Centre for Advanced Engineering study on Distributed Generation (DG) reported that it is a relatively new technology and capital costs remain high - in the $6,000-$10,000+/kWe range.

The future potential for fuel cells as on-site DG power plants is dependent on significant cost reductions, which the leading vendors believe will occur with volume. The molten carbonate technology and the solid oxide technology both achieve close to 50% fuel to electricity efficiency and both have exhaust heat suitable for combined cycle plants and CHP. The current technology has nearly zero emissions of NOx and can achieve comparable efficiency to the largest combined cycle gas turbine (CCGT) central plant.

The current capital costs per kilowatt of capacity and uncertainties about the component lives have limited fuel cell penetration of the DG market. At the end of 2001, there was a worldwide total of only 45 MWe of fuel cell capacity with 1 GWe projected for 2006.

Fuel Cell Technology	Electrolyte	Operating Temperature	Efficiency	Fuel Requirement
PEM (proton-exchange membrane)	*Polymer*	75 C (180°F)	35–60%	*Pure hydrogen or methanol (Natural gas requires a fuel reformer)*
PA (phosphoric acid)	*Phosphoric acid*	210 C (400°F)	35–50%	*Hydrogen, but not as pure as PEM (Natural gas requires a fuel reformer)*
MC (molten carbonate)	*Molten carbonate salt*	650 C (1200°F)	40–55%	*Hydrogen, natural gas (integrated reformer)*
SO (solid oxide)	*Ceramic*	800–1000 C (1500–1800°F)	45–60%	*Hydrogen, hydrocarbons (no separate reformer)*

Source: Centre for Advanced Engineering

Table A13.1. Fuel Cell types

Appendix 14

Stewart Island

The problem of high energy prices on Stewart Island have been studied a number of times over the years.

Figure A14.1

Early Studies

Studies in the mid 1980's identified several options that could provide electricity to the island. These included a cable from the mainland, diesel, LPG or fuel oil powered plant, wind, wave and hydro as well as biomass.

These studies were undertaken using an expected maximum demand of 480 kW and an annual energy output of 2700 kWh in 1988 rising to an expected maximum demand of 975 kW and an annual energy output of 5950 kWh in 2007. It was recognised that if the electricity demand did not increase as expected then the hydro option would not be economic. The reports were done when the electricity supply was not centralised and the estimates were arrived at after a survey was carried out on the island.

The cable from the mainland, while considered economic, would be exposed to potential damage from oyster dredges, ship's anchors and possible shifting sand bars. LPG was considered to be the least economic option mainly due to delivered fuel cost.

The favoured options were diesel (or 220 sec fuel oil), hydro, and wave power. The hydro and wave options had diesel generation as a back up. Diesel was generally favoured as it was widely used and people were experienced in handling and using it. A hydro scheme on the Toitoi River was capital intensive and required hydrological investigations and environmental assessments. Wave power options considered were Norwegian and American sourced plants

The load growth envisaged earlier did not eventuate but a centralised diesel power station was subsequently built. It runs automatically, units start and stop as needed.

Present Situation

Currently there are 350 connections and the average load is 6000 kWh per day. This load is supplied by, three 208 kW diesels, and one 320 kW unit. There is some load growth and a 550 kW diesel (ex standby unit at West Arm) has just been purchased to cope with this and any future increases. Annual peak demand is 480 kW (has been as high as 600 kW in the past), and a daily peak around 320 kW.

Few homes have electric ranges or water heaters. There is a night rate tariff of cheaper power for residential and commercial customers, at 28c/kWh to encourage customers to use commercial freezers and other higher power equipment. This was introduced to reduce the diesel fuel consumption rate by reducing low load running. Normal tariff is 40 c/kWh with diminishing rate for high users at 30 c/kWh.

Renewable Energy Opportunities

Wind
Studies carried out over two years confirm that the wind resource is too low (average 3 to 4 m/s) to be economic. While there are gusty periods there are long periods of low wind speeds.

Wave
Wave power has also been investigated but the resource is on the opposite coast from the load. Transmission costs across the island to get the power to the users make this energy source uneconomic at present.

Hydro
Hydro power is still potentially available but the engineering and environmental studies would need to be carried out to see if the resource is viable and economic. The early studies had a 1.2 MW station upgradeable to 2.4 MW. This is higher than the current needs, load growth may make this an option in the future.

Solar Hot Water
What ever energy source is used for water heating, solar hot water can be used to supplement existing hot water systems and be a serious consideration for new buildings.