Revised Final Report

# Heavy Industry Energy Demand Update Report

Prepared for

## Ministry of Economic Development

February 2009

covec

expert analysis + practical advice

Covec is an applied economics practice that provides rigorous and independent analysis and advice. We have a reputation for producing high quality work that includes quantitative analysis and strategic insight. Our consultants solve problems arising from policy, legal, strategic, regulatory, market and environmental issues, and we provide advice to a broad range of companies and government agencies.

Covec develops strategies, designs policy, and produces forecasts, reports, expert testimony and training courses. Our commitment to high-quality, objective advice has provided confidence to some of the largest industrial and governmental organisations in Australasia.

**Authorship**

This document was written by Tim Denne, Ian Twomey and Richard Hale. For further information email tim@covec.co.nz or phone (09) 916-1960

**Disclaimer**



covec
expert analysis + practical advice

Covec Limited  Level 15  Qantas House  191 Queen Street
PO Box 3224  Shortland Street  Auckland  New Zealand
t: (09) 916-1970  f: (09) 916-1971  w: www.covec.co.nz

# Contents

# Executive Summary

This report is an update to a 2006 report that developed projections of energy demand by a number of energy-intensive manufacturing industries in New Zealand.[1] This report includes new information and new projections; it also provides information on some industries that were not included in the original report.

Energy demand is projected by MED using its Supply and Demand Energy Model (SADEM). Energy demand in most industries is modelled econometrically as a single aggregate on the basis of historical relationships between industrial energy demand and aggregate economic activity, measured as GDP. However, for a number of industries, energy demand is very "lumpy", ie there are a small number of large plants with significant energy demand. Changes in these industries can have a significant impact on total energy demand; for example, energy price increases can lead to plant closures or significant changes in levels of production. For this reason, a number of individual industries are modelled separately within SADEM. This allows known information about plant capacity changes to be taken into account and for relationships between prices and demand to be analysed at a more detailed, firm level.

The industries that are analysed in this report are:

- Aluminium production
- Steel production
- Cement and lime manufacture
- Petrochemicals production
- Oil refining
- Dairy processing
- Meat processing
- Timber processing

The report has been produced during a time of extraordinary change in the global economy with wide-ranging impacts on commodity markets, prices and demand. The full effects of these changes and an understanding of their longevity are still to be understood fully. The results in this report do not fully take these into account; it takes a longer run perspective to provide inputs to long run projections of energy demand. The underlying assumption is that levels of demand will return to reflect historical trends.

## Aluminium Production

Energy demand at the smelter is chiefly electricity. Total demand is set by a combination of limitations in the supply contract plant capacity and optimal energy intensities.

However, it is the electricity demand that defines the output and improvements in energy efficiency would lead to increased levels of output rather than reductions in electricity demand. The key issue determining future production will be overall production economics and whether the plant continues in operation and the key determining factors will be commodity (aluminium) price, exchange rates and the electricity price.

---

[1] Covec, Hale & Twomey and Exergi Consulting Ltd (2006) Heavy Industry Energy Demand. Prepared for Ministry of Economic Development, http://www.med.govt.nz/templates/MultipageDocumentTOC____21873.aspx.

Projections of future energy demand are provided in Table ES1.

**Table ES1** Projected Energy Demand (PJ) at Tiwai Point

| | Electricity | Heavy Fuel Oil | Coke & pitch | Total |
|---|---|---|---|---|
| 2010 | 20.3 | 1.0 | 5.7 | 27.0 |
| 2015 | 20.6 | 1.1 | 5.8 | 27.5 |
| 2020 | 20.6 | 1.1 | 5.8 | 27.5 |
| 2025 | 20.6 | 1.1 | 5.8 | 27.5 |
| 2030 | 20.6 | 1.1 | 5.8 | 27.5 |
| 2035 | 20.6 | 1.1 | 5.9 | 27.6 |

## Steel Production

There are two steel plants in New Zealand: the Glenbrook steel mill, owned and operated by New Zealand Steel Ltd, a wholly owned subsidiary of BlueScope Steel Ltd and the smaller Pacific Steel mill located in Auckland and owned by Fletcher Building Ltd.

As for the aluminium smelter, steel production is vulnerable to exchange rates (it sells in US$ and pays costs in NZ$) and commodity prices. Projections of future energy demand are given below.

**Table ES2** Projected Energy Demand –Steel Production

| | Coal | Grid Electricity | Total electricity | Gas | Diesel | Coke | Direct CO2 |
|---|---|---|---|---|---|---|---|
| 2010 | 17.5 | 2.4 | 4.57 | 2.49 | 0.07 | 0.18 | 1,776 |
| 2015 | 18.2 | 2.6 | 4.72 | 2.52 | 0.07 | 0.19 | 1,793 |
| 2020 | 18.2 | 2.6 | 4.72 | 2.54 | 0.07 | 0.19 | 1,809 |
| 2025 | 18.2 | 2.6 | 4.72 | 2.56 | 0.07 | 0.19 | 1,882 |
| 2030 | 18.2 | 2.6 | 4.72 | 2.59 | 0.07 | 0.19 | 1,884 |
| 2035 | 18.2 | 2.6 | 4.72 | 2.59 | 0.07 | 0.19 | 1,885 |

## Cement and Lime

There are two producers of cement in New Zealand: Holcim (New Zealand) Ltd, that operates a cement plant in Westport, and Golden Bay Cement that operates a plant in Whangarei. Holcim is considering closing its existing plant and building a new, larger plant; this would have a significant impact on energy use.

Three companies produce burnt lime. Projected energy demand across the two industries is given below.

**Table ES3** Projected Cement and Lime Energy Use and $CO_2$ Emissions

| | Coal (TJ) | Diesel (TJ) | Waste oil (TJ) | Woodwaste (TJ) | Gas (TJ) | Electricity (TJ) | Total (TJ) | Total MT $CO_2$ |
|---|---|---|---|---|---|---|---|---|
| Cement (old) | 4,376 | 85 | 500 | 386 | | 554 | 6,240 | 1.16 |
| Cement (new) | 4,664 | 90 | 565 | 386 | | 691 | 6,735 | 1.34 |
| Lime | 1,430 | 5 | | | 18 | 26 | 1,479 | 0.27 |

## Petrochemicals

Petrochemical production in New Zealand includes methanol and fertiliser production. The key vulnerabilities relate to the costs of gas for methanol production and commodity prices. Projections of future energy demand are given below.

**Table ES4** Annual Energy Demand Projection for Petrochemicals Production

| | Methanol | | | | Urea | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Production (kt) | gas intake (PJ) | Consump-tion (PJ) | Embodied (PJ) | Production (kt) | gas intake (PJ) | Consump-tion (PJ) | Embodied (PJ) | Electricity GWh | Total $CO_2$ methanol + urea (kt) |
| 2010 | 853 | 34.0 | 19.7 | 14.3 | 250 | 7.0 | 3.5 | 3.5 | 30 | 923 |
| 2011 | 853 | 34.0 | 19.7 | 14.3 | 250 | 7.0 | 3.5 | 3.5 | 30 | 923 |
| 2012-15 | 477 | 19.0 | 11.0 | 8.0 | 250 | 7.0 | 3.5 | 3.5 | 30 | 596 |
| 2016-35 | 0 | 0 | 0 | 0 | 250 | 7.0 | 3.5 | 3.5 | 30 | 181 |

## Oil Refining

New Zealand has one oil refinery located at Marsden Point near Whangarei. The refinery processes crude oils (largely imported) and residues into a range of products for the New Zealand market. These products include petrol, jet fuel, kerosene, diesel, fuel oil and bitumen.

**Table ES5** Oil Refining - Projected Energy Demand and Emissions

| | Prod-uction | Prod-uction | Fuel use | Oil consumption | Oil consumption | Electri-city efficiency | Electricity use | Electricity | CO2 |
|---|---|---|---|---|---|---|---|---|---|
| | Mt | Mbbls | % | kt | PJ | kWh/t | GWh | PJ | Mt |
| 2010 | 5.3 | 42.1 | 7.1% | 379.0 | 17.1 | 52.2 | 277.5 | 1.00 | 1.23 |
| 2015 | 5.3 | 42.1 | 7.0% | 374.3 | 16.8 | 51.5 | 273.9 | 0.99 | 1.22 |
| 2020 | 5.3 | 42.1 | 7.0% | 369.7 | 16.6 | 50.9 | 270.4 | 0.97 | 1.20 |
| 2025 | 5.3 | 42.1 | 6.9% | 365.1 | 16.4 | 50.2 | 266.8 | 0.96 | 1.19 |
| 2030 | 5.3 | 42.1 | 6.8% | 360.5 | 16.2 | 49.5 | 263.3 | 0.95 | 1.17 |
| 2035 | 5.3 | 42.1 | 6.7% | 356.0 | 16.0 | 48.8 | 259.7 | 0.93 | 1.16 |

## Dairy Processing

Energy is used in the dairy industry largely for drying milk to produce milk powder. Dairy production has expanded significantly in recent years and is expected to continue to do so. Energy demand will increase accordingly.

Projections of demand are given below including demand in North and South Islands.

**Table ES6** Dairy Energy Projections

| | Milksolids (kt) | Electricity Own generation | Electricity Grid | Electricity Total | Electricity grid | Gas | Coal | $CO_2$ |
|---|---|---|---|---|---|---|---|---|
| | NZ | NI | NI | NI | SI | NI | SI | kt |
| 2010 | 1,509 | 560 | 82 | 642 | 427 | 18.3 | 9.5 | 1,766 |
| 2011 | 1,561 | 560 | 87 | 647 | 459 | 18.4 | 10.2 | 1,816 |
| 2012 | 1,603 | 560 | 91 | 651 | 485 | 18.5 | 10.8 | 1,853 |
| 2015 | 1,725 | 560 | 94 | 654 | 569 | 18.6 | 12.6 | 1,957 |
| 2020 | 1,910 | 560 | 106 | 666 | 688 | 18.9 | 15.3 | 2,086 |
| 2025 | 2,029 | 560 | 109 | 669 | 769 | 19.0 | 17.1 | 2,125 |
| 2030 | 2,158 | 560 | 118 | 678 | 851 | 19.2 | 18.9 | 2,164 |
| 2035 | 2,309 | 560 | 125 | 685 | 951 | 19.4 | 21.1 | 2,218 |

## Meat Processing

There are approximately 33 meat processors in New Zealand and 100 meat exporters. Thermal energy, in the form of steam and hot water, is used for cleaning and sterilising and for rendering (heating meat products to produce meat meal and tallow). Electricity is used for the operation of machinery and for refrigeration, ventilation, lighting and the production of compressed air.

Energy demand projections are given below.

**Table ES7** Meat Processing Energy Demand Projections (TJ)

| | Kt meat | Electricity | Coal | Lignite | Natural gas | LPG | Fuel oil | Total |
|---|---|---|---|---|---|---|---|---|
| 2010 | 1,131 | 2,173 | 1,919 | 1,010 | 1,562 | 92 | 26 | 6,782 |
| 2015 | 1,149 | 2,210 | 1,956 | 1,032 | 1,582 | 93 | 27 | 6,901 |
| 2020 | 1,149 | 2,210 | 1,956 | 1,032 | 1,582 | 93 | 27 | 6,901 |
| 2025 | 1,149 | 2,210 | 1,956 | 1,032 | 1,582 | 93 | 27 | 6,901 |
| 2030 | 1,149 | 2,210 | 1,956 | 1,032 | 1,582 | 93 | 27 | 6,901 |
| 2035 | 1,149 | 2,210 | 1,956 | 1,032 | 1,582 | 93 | 27 | 6,901 |

## Timber Processing

The timber processing sector includes pulp & paper production, sawmilling and panels production. The sector is currently made up of four significant players; Carter Holt Harvey, Norske Skog, Pan Pac and Winstone Pulp with a number of other smaller players. The majority of energy use in the sector is in pulp and paper production (78%), with approximately 13% in panels and 9% in sawmills.

Projections of total energy demand for the sector is given below.

**Table ES8** Total Primary Energy Demand by Sub-sector and fuel (PJ)

| Year | Pulp & Paper | Saw-milling | Panels | Coal | Gas | Diesel | Geo-thermal | LPG | Biomass | Elec-tricity | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | 81.2 | 9.0 | 13.6 | 1.4 | 6.3 | 0.5 | 49.0 | 0.3 | 36.6 | 9.6 | 103.8 |
| 2015 | 81.2 | 9.6 | 13.6 | 1.5 | 6.4 | 0.5 | 49.0 | 0.3 | 37.1 | 9.6 | 104.4 |
| 2020 | 81.2 | 10.2 | 13.6 | 1.5 | 6.5 | 0.5 | 49.0 | 0.3 | 37.5 | 9.6 | 105.0 |
| 2025 | 81.2 | 10.8 | 13.6 | 1.5 | 6.6 | 0.5 | 49.0 | 0.3 | 38.0 | 9.6 | 105.6 |
| 2030 | 81.2 | 11.1 | 13.6 | 1.5 | 6.7 | 0.5 | 49.0 | 0.3 | 38.3 | 9.6 | 105.9 |
| 2035 | 81.2 | 11.1 | 13.6 | 1.5 | 6.7 | 0.5 | 49.0 | 0.3 | 38.3 | 9.6 | 105.9 |

# 1. Introduction

This report is an update to a 2006 report that developed projections of energy demand by a number of energy-intensive manufacturing industries in New Zealand.[2] This report includes new information and new projections; it also provides information on some industries that were not included in the original report.

Energy demand is projected by MED using its Supply and Demand Energy Model (SADEM). Energy demand in most industries is modelled econometrically as a single aggregate on the basis of historical relationships between industrial energy demand and aggregate economic activity, measured as GDP. However, for a number of industries, energy demand is very "lumpy", ie there are a small number of large plants with significant energy demand. Changes in these industries can have a significant impact on total energy demand; for example, energy price increases can lead to plant closures or significant changes in levels of production. For this reason, a number of individual industries are modelled separately within SADEM. This allows known information about plant capacity changes to be taken into account and for relationships between prices and demand to be analysed at a more detailed, firm level.

The industries that are analysed in this report are:

- Aluminium production
- Steel production
- Cement and lime manufacture
- Petrochemicals production
- Oil refining
- Dairy processing
- Meat processing
- Timber processing

The report has been produced during a time of extraordinary change in the global economy with wide-ranging impacts on commodity markets, prices and demand. The full effects of these changes and an understanding of their longevity are still to be understood fully. The results in this report do not fully take these into account; it takes a longer run perspective to provide inputs to long run projections of energy demand. The underlying assumption is that levels of demand will return to reflect historical trends.

[2] Covec, Hale & Twomey and Exergi Consulting Ltd (2006) Heavy Industry Energy Demand. Prepared for Ministry of Economic Development, http://www.med.govt.nz/templates/MultipageDocumentTOC____21873.aspx.

# 2. Aluminium Production

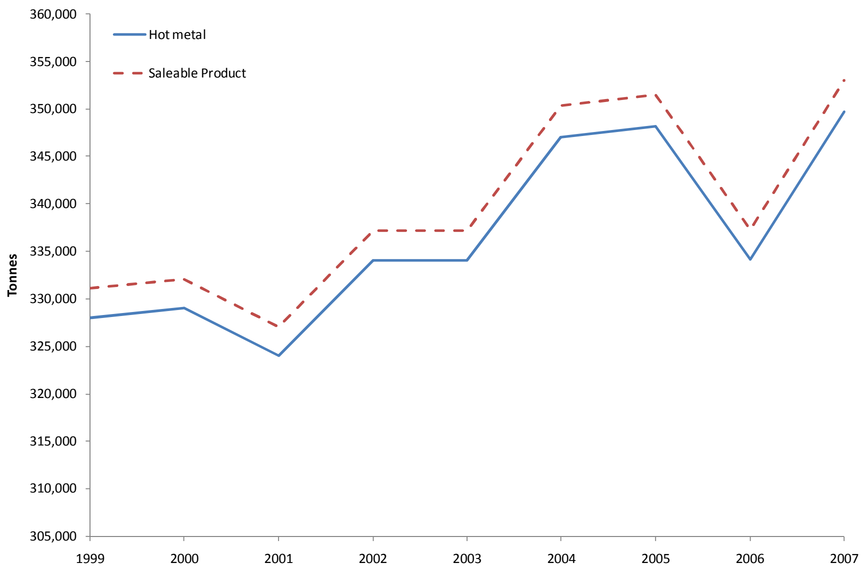
## 2.1. Tiwai Point Smelter

There is a single aluminium smelter plant in New Zealand, at Tiwai Point near Bluff in Southland, operated by New Zealand Aluminium Smelters (NZAS). The Tiwai Point smelter is a tolling operation in which the NZAS owners—Rio Tinto Alcan (New Zealand) Ltd (79.4% of shares) and Sumitomo Chemical Company Ltd (20.6%) contribute raw material and pay a tolling fee for conversion of alumina to primary aluminium products. Production activities at the smelter include manufacturing of carbon anodes, aluminium production (smelting) in reduction lines, and casting of molten metal into aluminium products.

Aluminium plants produce a number of different products some of which are alloys incorporating other materials. The total weight of saleable products can be greater than the weight of aluminium produced. However, the plant's capacity is specified with respect to its production of hot aluminium metal.

The Tiwai Point smelter has a capacity of approximately 360,000 tonnes (hot metal) per annum but is constrained from producing at capacity by its electricity contract (see Section 2.2 below) and total production is determined by electricity consumption constraints (or optima)[3] more than output constraints. Production in 2007 was 353,000 tonnes of saleable products and approximately 350,000 tonnes of hot metal.[4] Production in 2006 was lower than recent trends (Figure 1); this corresponded to a period of high spot electricity prices that resulted in lower production levels in the first half of that year.

**Figure 1** Tiwai Point Production



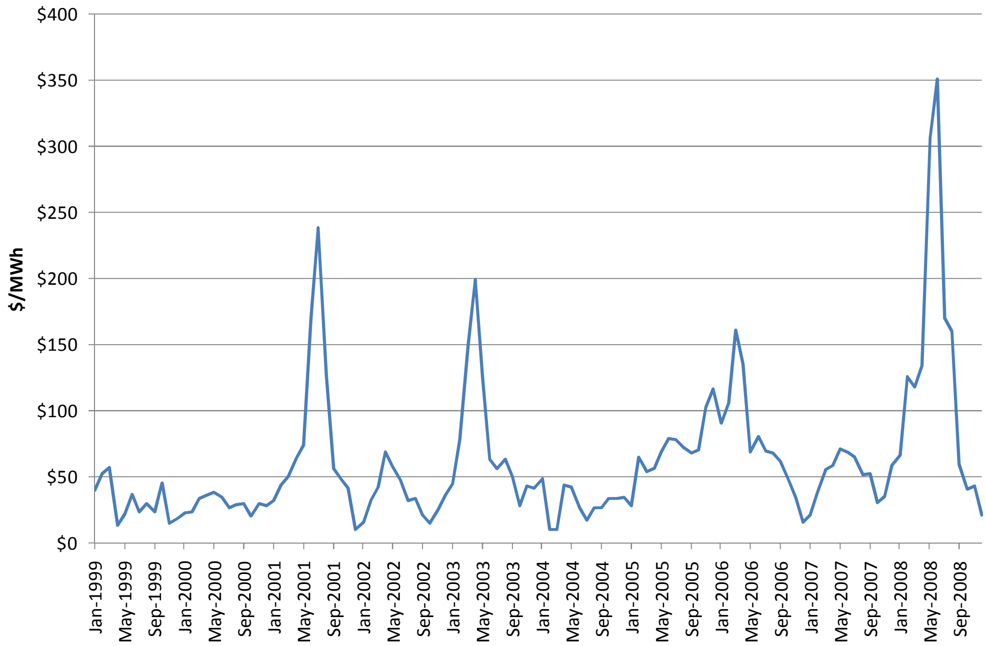

Source: Rio Tinto Sustainable Development Reports; Covec analysis

[3] There is an efficient level of production defined by electricity demand per unit of output

[4] New Zealand Aluminium Smelters Ltd (2008) Our people, our operations, our community.

Similar reductions from trend growth occurred in 2001 and 2003 when spot electricity prices were high (Figure 2). Production cuts also occurred in 2008 because of the very high prices.

**Figure 2** Average Wholesale Monthly Electricity Prices - Benmore




Source: Monthly Final Prices, Comit Free to Air (www.electricityinfo.co.nz/comitFta)

Production cuts reflect the nature of the contract for electricity supply at the smelter. The current contract that runs through to the end of 2012 has two elements.

- A contracted component delivered under a take or pay contract, the price of which is related to the spot price (average for NZ), but lagged by one year. The change in contract price is limited to 15% per annum. This comprises approximately 90% of current electricity consumption at the plant (543.75MW).

- A spot price component for 10% of consumption.

The take or pay contract means that only 10% of its costs can be avoided. This means that short run production cuts made when spot prices are high are only of up to 10%. Low lake levels have also meant some physical constraints on the quantities of electricity delivered to Tiwai Point; under the contract with Meridian, some of the smelter's electricity supplies can be withdrawn under low supply conditions—NZAS has chosen not to supplement supplies with purchases from other electricity suppliers.

In early November 2008 a transformer was lost resulting in a peak load of approximately 420MW (approximately 70% of capacity). The transformer is due to be repaired in early 2009 but will take at least 3-4 months (possibly twice as long) to get back to full operations. Another transformer is on order with potentially another one being ordered shortly. This investment would be sufficient for the smelter to reach

640MW of peak load and 370,000 tonnes of output (see below) although optimal electricity consumption is likely to be lower than this.

## 2.2. Future Production Levels

Currently production levels are limited by the electricity supply contract. The smelter operates under the Tiwai Point Connection Contract (TPCC) under which there is a maximum of 610MW of peak electricity load until the end of 2012 (expiry of TPCC). This constrains the smelter as it can consume 620MW at full cell capacity (360,000 tonnes of hot metal). NZAS hoped to renegotiate the contract to increase load to 620MW by January 2009 but this is now delayed because of the transformer loss and ongoing contractual discussions. We assume that 620MW is achieved by January 2010. Potential consumption of 640MW may be achieved by January 2011 (equivalent to output of approximately 370,000 tonnes) but optimal consumption may be less than this, ie tonnes of hot metal per MWh of consumption may be falling as it approaches 640MW. We assume that consumption rises to 630MW only. In the long term increasing production to over 400,000 tonnes of hot metal (700MW of peak electricity demand) is possible but would require significant capital investment ($200million) which would depend in turn on long term electricity price contracts and sufficiently high metal prices.

We assume that, if the plant continues to operate, it will reach 630MW of consumption in 2012 but not increase beyond this level. Constraints on achieving this level have been associated somewhat with electricity availability and transmission capacity, and it is assumed that significant additional electricity supply, eg from wind, may be available in the South Island by the end of 2012 and that there will be some transmission reinforcement.

We do not assume additional growth in capacity at Tiwai Point. The focus of international growth in capacity is focussed on Asia and Europe; Figure 3 shows historical and future capacity (to 2010) estimated by the International Aluminium Institute.

**NZAS Competitive Advantage**

New Zealand's competitive advantage in aluminium production is in the purity of its product and its energy efficiency. At 99.98% pure, NZAS production is the highest purity aluminium worldwide.[5] Such super pure aluminium can be used for some special applications—typically those where high ductility or conductivity is required.[6]

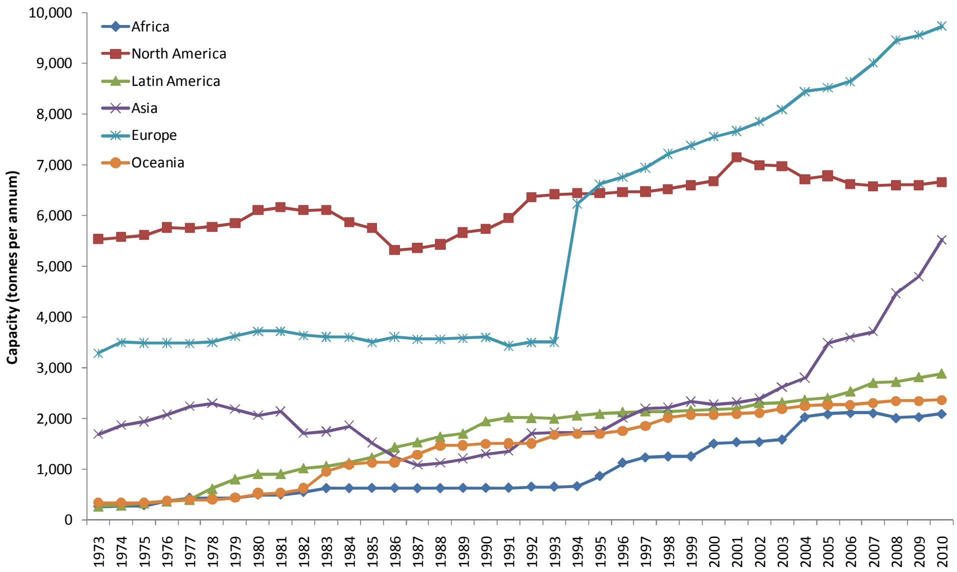
Electricity demand (see below) is one of the lowest in the world (see Figure 4 for NZAS compared to average energy efficiencies in different markets). Energy efficiency of production has been improving steadily over time (see below) and the company aims to continue improvements.

---

[5] New Zealand Aluminium Smelters Ltd (2007) Our people, our operations, our community. http://www.riotinto.com/riotintoalcan/documents/NZAS_2007_SD_Report_-_final.pdf

[6] http://www.world-aluminium.org/

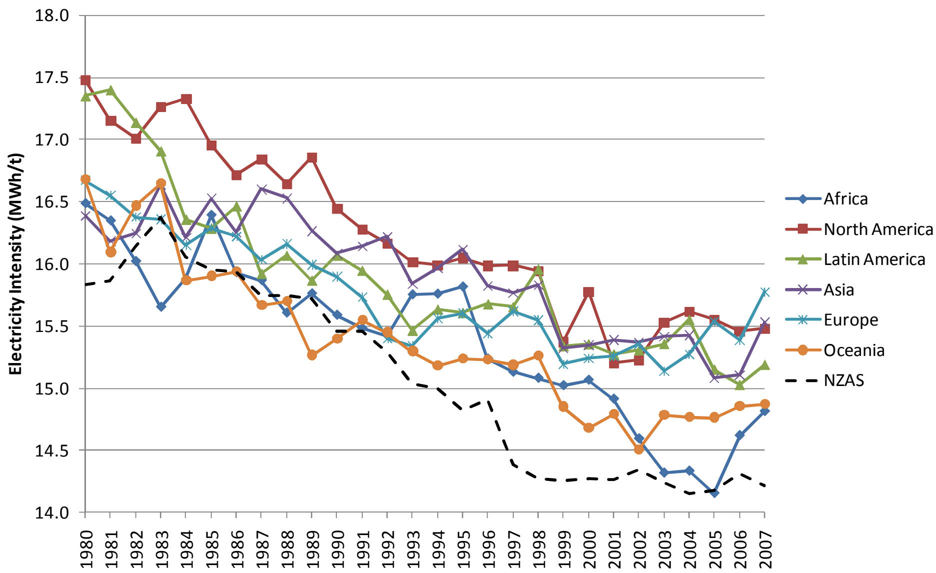
**Figure 3** Primary Aluminium Production Capacity




Source: International Aluminium Institute (www.world-aluminium.org)

Low electricity prices have provided a competitive advantage to production at Tiwai Point. Historically, NZAS had access to low cost electricity, notionally from Manpouri, under long-term contract. However, the current terms of the electricity contract include a link to spot prices. Average prices paid in the year to March 2007 were approximately $52/MWh including lines charges and $45.7/MWh as energy charges.[7] These costs are lower than in some countries, but NZAS's electricity costs are expected to rise in the future.

**Figure 4** Average Energy Efficiency of Aluminium Production




Source: www.world-aluminium.org

[7] Estimated from: Ministry for Economic Development (2008) Energy Data File July 2008. Taken from electricity consumption and costs for the non-ferrous metals sector.

## 2.3. Energy Intensity of Production

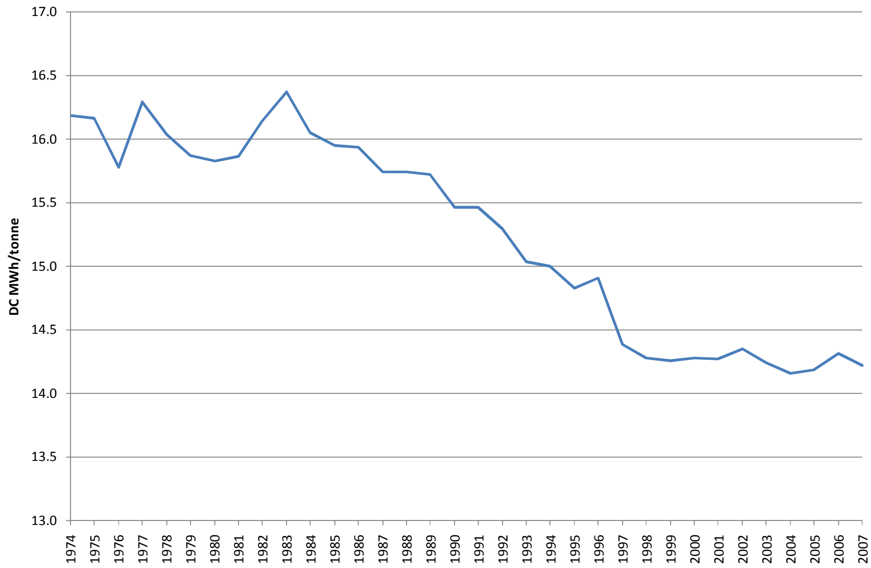
Primary aluminium is produced by an electrolytic process in which alumina is reduced to aluminium metal. In 2007 the Tiwai Point smelter had an electricity requirement in production of 14.22 DC MWh/t Al and a total consumption of 5,324 GWh. The total includes an amount to take account of losses (approximately 2%) in the conversion from AC to DC, and electricity consumed in other uses at the plant.

Instantaneous demand at the site is approximately 610MW.[8]

In addition to the use of electricity, heavy fuel oil is used as an input fuel for the furnace which is used to bake carbon anodes. Current use amounts to approximately 23,000 tonnes per annum. The energy value of heavy fuel oil is 43.03MJ/kg, so this amount is equivalent to approximately 2.83 GJ/t Al. In addition there is a significant amount of coke and pitch used in anode production; this amounted to 5.3PJ in 2007, a rate of approximately 15.2GJ/t Al.

Electricity intensity of production has been improving steadily over time but despite goals of improving efficiency, it has appeared to plateau in recent years (Figure 5). NZAS aims to reduce its energy demand to 14.11 MWh/t in 2008.[9] With additional energy efficiency improvements, it had been suggested previously that its electricity intensity might eventually reach levels below 14MWh/t. Lowest achievable energy intensity of production internationally is estimated as 12.9MWh/t Al,[10] but this is not possible as a retrofit option.

**Figure 5** Electricity Intensity of Production at Tiwai Point (DC MWh/t)




Source: Rio Tinto

[8] Including approximately 585MW for production and 25MW for other uses at the plant.

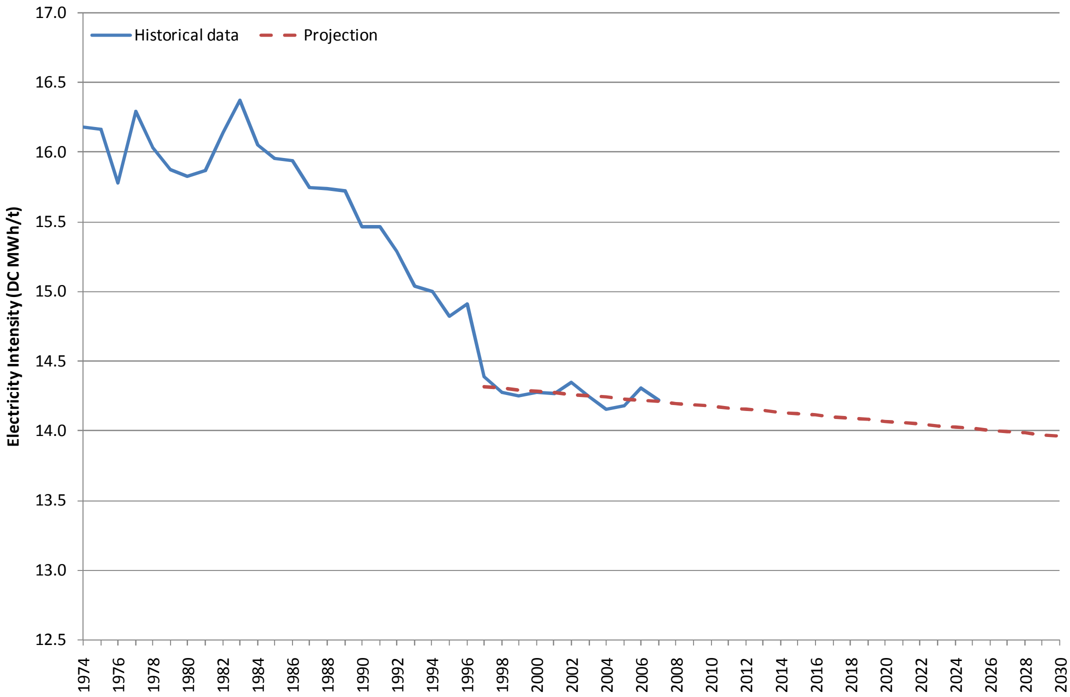
[9] NZAS (op cit)

[10] European Commission (2001) Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques in the Non Ferrous Metals Industries

However, it is important to note that improvements in electricity efficiency will not be taken up as reduced electricity consumption but as increased output of metal.

We use a simple linear regression over the period from 1997 to derive a trend as shown in Figure 6; it is less optimistic than Rio Tinto's goals set out in its sustainable development reports. It results in a value of 14.2MWh/t in 2008, 14.1 MWh/t in 2018 and 14.0 MWh/t in 2027.

**Figure 6** Projected Production Electricity Intensity




## 2.4. Greenhouse Gas Emissions

Greenhouse gas emission factors are listed in Table 1. There are direct emissions of $CO_2$ associated with the oxidation of carbon anodes and from the fuel oil used to bake the anodes. PFCs are released intermittently when aluminium oxide levels drop too low.

**Table 1** Aluminium - Greenhouse Gas Emission Factors

| Emission source | t C/t Al | t $CO_{2-e}$/t Al (as hot metal) |
|---|---|---|
| Process | 0.41 | 1.56 (3.812 **t $CO_{2-e}$/t C** conversion factor) |
| PFCs | | 0.25 |
| Heavy fuel oil | | (c 0.2) |
| Total | | 2.01 |

This excludes any emissions associated with electricity consumption, ie Tiwai Point's consumption means less hydro is available to displace thermals.

## 2.5. Energy Projection

Assuming ongoing production at the site (alternative assumptions are explored below), total projections of energy consumption at the aluminium smelter are shown in Table 2.

**Table 2** Projected Energy Demand (PJ) at Tiwai Point

| | Electricity | Heavy Fuel Oil | Coke & pitch | Total |
|---|---|---|---|---|
| 2007 | 19.2 | 1.0 | 5.3 | 25.5 |
| 2008 | 18.3 | 1.0 | 5.3 | 24.6 |
| 2009 | 17.1 | 0.9 | 4.8 | 22.8 |
| 2010 | 20.3 | 1.0 | 5.7 | 27.0 |
| 2015 | 20.6 | 1.1 | 5.8 | 27.5 |
| 2020 | 20.6 | 1.1 | 5.8 | 27.5 |
| 2025 | 20.6 | 1.1 | 5.8 | 27.5 |
| 2030 | 20.6 | 1.1 | 5.8 | 27.5 |
| 2035 | 20.6 | 1.1 | 5.9 | 27.6 |

## 2.6. Production Constraints

Levels of total production at the site are more important than changes in electricity intensity in determining total energy demand at Tiwai Point. There are a number of factors that will determine ongoing production: the price of electricity, exchange rates, emissions prices and the market price of aluminium.

Total costs of production estimated under a number of critical assumptions are listed in Table 3; these include an electricity price of $80/MWh.

**Table 3** Aluminium Production Costs

| | Assumption 1 | Assumption 2 | US$ | NZ$ @ US$0.6 | NZ$/t Al (hot metal) | $million |
|---|---|---|---|---|---|---|
| Alumina | 1.91 t/t Al | 13% of Al price | $325/t alumina | $542/t alumina | $1,035/t | $362 |
| Electricity | 14.2MWh/t Al production | 15.2MWh/t whole site | | $80/MWh | $1,216/t | $426 |
| Direct Emission Costs | 2.01t $CO_{2-e}$/t | | | $25/t $CO_2$ | $50/t | $18 |
| Other | | | | | $462/t | $162 |
| Pot replacement | | | | | $155/t | $54 |
| Total | | | | | $2,918/t | $1,021 |
| Aluminium Sales | 1.0094 t product/ t hot metal | | $2,500/t | $4,167/t | $4,206/t | $1,472 |
| EBIT | | | | | $1,288/t | $451 |

EBIT is not necessarily the best measure of whether the smelter will continue in production. A return on capital will be required also. This is estimated at approximately $115/tonne or approximately $40 million in total per annum. Inclusion of this factor in analysis requires some explanation. A firm will have invested in a plant with the expectation of a return on that capital. However, once the investment is made, this is a sunk cost and the return on capital will not affect ongoing production at the site; this is determined by a positive EBIT.[11] However, there is a requirement for ongoing capital spend and plant maintenance and this will only be undertaken if a positive return on that spend can be achieved.

The plant is made up of 658 individual cells that are continuously replaced (approximately 2 per week); these are the most significant plant capital costs and in practical terms are almost a variable cost of production. However, they are also removable and could be used in another plant. Through cell replacement, the whole plant is replaced every 6-7 years. The above analysis includes some capital investment in the form of ongoing replacement of pots; however it does not include depreciation costs which are a proxy for the plant replacement costs.

Table 4 uses these cost data to estimate the expected net returns to NZAS under a number of assumptions over aluminium prices and exchange rates. The net revenues are estimated as EBIT less a cost of capital. It provides a measure of the likelihood that production will continue, given different aluminium prices and exchange rates. The calculations include an electricity price of $80/MWh and an emissions price of $25/tonne. The results suggest that production is sensitive to the two key parameters: aluminium price and exchange rates; NZAS is favoured by a low exchange rate as the value of the output increases when converted to NZ$. Long run aluminium prices are uncertain but consensus forecasts taken as the mean of 22 independent forecasts suggest a price of close to US$2,700/tonne by 2010.[12] ABARE suggests that prices might fall to $1820 by 2011 but then rise again (to $2100 by 2013).[13] The lower prices are closer to costs of supply whereas the higher prices are maintained by shortfalls in supply over demand.

The shaded area is the situations under which ongoing production in New Zealand might be at risk.

In Figure 7 we add electricity price to the analysis, showing the impact of varying the electricity price on the cut-off values; in all cases, the area to the right of the lines represents circumstances under which the plant would be expected to continue in production, whereas the area to the left is at risk. One of the factors that will affect electricity prices is the inclusion of the electricity sector in the emissions trading system (ETS). The electricity price impacts of the ETS are uncertain and are the subject of ongoing analysis by MED and others.

---

[11] Note, any individual owner may require the achievement of a hurdle rate return on investment, but if, for example, a plant is revalued at scrap value because of the lack of a positive return on existing investment, this might at least lead to the continued use of the plant while it is run down either by the existing owner or new owner following a cut price sale.

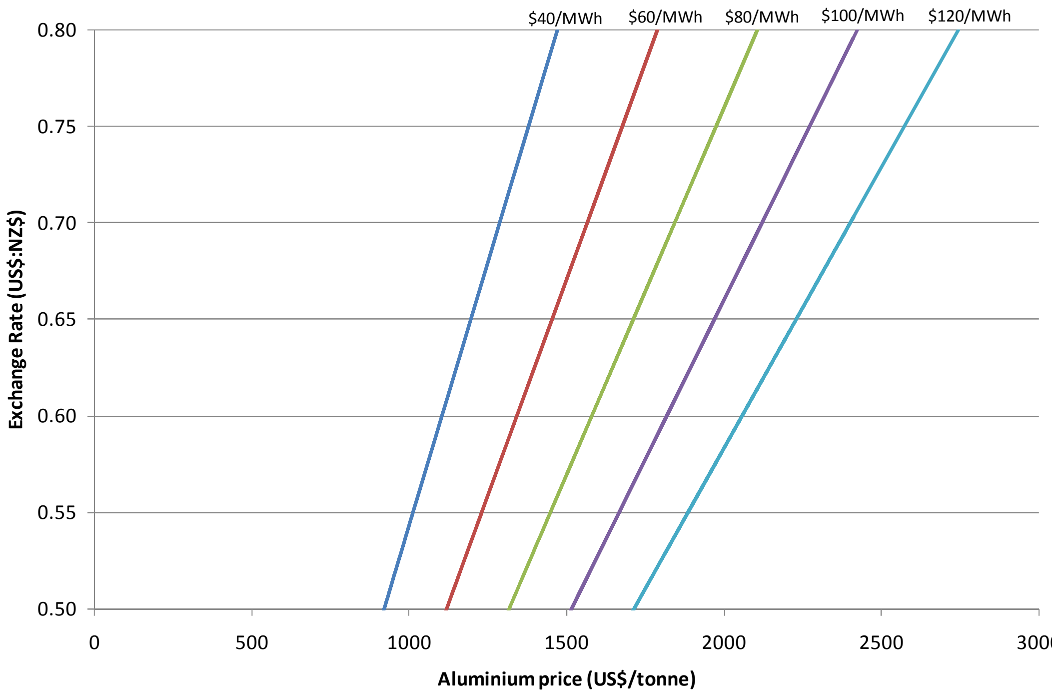
[12] Energy & Metals Consensus Forecasts. April 2008.

[13] ABARE (2008) Australian commodities 08.01

**Table 4** Net Revenue ($million)

| Aluminium | Exchange rate | | | | | | |
|---|---|---|---|---|---|---|---|
| price ($US) | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 |
| 1500 | 100 | 27 | -33 | -85 | -129 | -167 | -200 |
| 1600 | 153 | 76 | 11 | -44 | -90 | -131 | -167 |
| 1700 | 206 | 124 | 55 | -3 | -52 | -96 | -133 |
| 1800 | 260 | 172 | 100 | 38 | -14 | -60 | -100 |
| 1900 | 313 | 221 | 144 | 79 | 24 | -25 | -67 |
| 2000 | 366 | 269 | 189 | 120 | 62 | 11 | -33 |
| 2100 | 419 | 318 | 233 | 161 | 100 | 47 | 0 |
| 2200 | 473 | 366 | 277 | 202 | 138 | 82 | 33 |
| 2300 | 526 | 415 | 322 | 243 | 176 | 118 | 66 |
| 2400 | 579 | 463 | 366 | 284 | 214 | 153 | 100 |
| 2500 | 633 | 511 | 411 | 325 | 252 | 189 | 133 |
| 2600 | 686 | 560 | 455 | 366 | 290 | 224 | 166 |
| 2700 | 739 | 608 | 499 | 407 | 328 | 260 | 200 |
| 2800 | 792 | 657 | 544 | 448 | 366 | 295 | 233 |
| 2900 | 846 | 705 | 588 | 489 | 404 | 331 | 266 |
| 3000 | 899 | 754 | 633 | 530 | 442 | 366 | 300 |

**Figure 7** Impacts of Exchange rate, aluminium price and electricity price on profitability



# 3. Steel Production

## 3.1. Background

There are two steel plants in New Zealand:

- the Glenbrook steel mill, owned and operated by New Zealand Steel Ltd, a wholly owned subsidiary of BlueScope Steel Ltd; and
- the smaller Pacific Steel mill located in Auckland, owned by Fletcher Building Ltd.

### 3.1.1. Glenbrook Steel Mill

The Glenbrook steel mill is a fully integrated facility that transforms locally sourced ironsand (plus coal and limestone) into molten iron and then into steel. The mill produces around 600,000 tonnes of steel per annum, formed into a wide range of products. Around 50% of the mill's output is exported.

Energy, including coal, electricity and gas, is a major input cost in steelmaking. Its total electricity demand is approximately 1000GWh per annum, of which approximately 440GWh is drawn from the grid; this is approximately 1.1% of total NZ electricity demand. Coal consumption is approximately 17PJ per annum; this has compared with total NZ demand of 68-94 PJ over the last five years.[14]

### 3.1.2. Pacific Steel

Pacific steel manufactures rods and reinforcing bars for domestic and export markets. It uses an electric arc furnace process and has an electricity demand of approximately 200GWh per annum spread across the steel mill and rolling mill.

## 3.2. Production Levels

### 3.2.1. NZ Steel

New Zealand Steel's Glenbrook Plant has a nominal capacity of 625,000 tonnes of raw steel. A significant plant expansion has been considered for some time; it would increase production levels providing products for export. However, the prospect of an economic instrument (tax or emissions trading system) for $CO_2$ emissions has been considered a limiting factor on this expansion. The introduction of an emissions trading system (ETS) and the planned phase-out of the free allocation of emission units has considerably reduced the likelihood of this investment. Given this, the plant expansion has not been included in the projections here.

Production levels have been slightly down in recent years (Figure 8) owing to a number of operational issues but remain close to 600,000 tonnes. Tonnes of product are less than that of raw steel and the ratio differs year-on-year reflecting changes in product mix and inventory levels. Domestic demand for steel has been increasing, although it peaked in

[14] MED (2008) Energy Data File June 2008.

2004/05; immediate future domestic demand levels are expected to be below trend because of a downturn in construction activity.

**Figure 8** Steel Production - NZ Steel

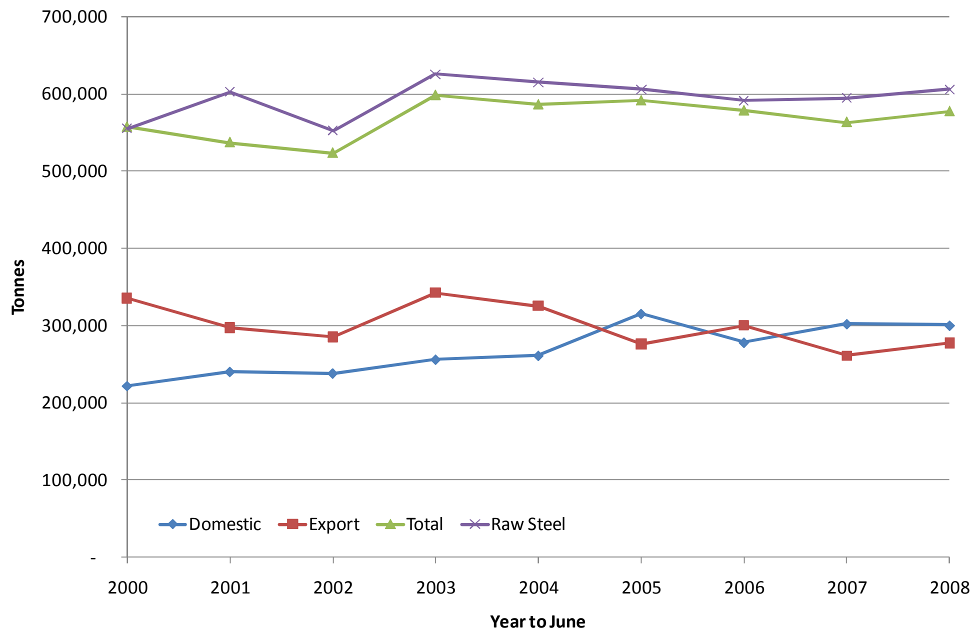



Table 5 shows production data for NZ Steel, along with financial performance data that are used below to estimate the vulnerability of the plant to emissions prices.

**Table 5** NZ Steel Production Data

| | Raw Steel (kt) | Dispatch of steel (kt) | | | Financial performance (A$M) | | Financial performance (NZ$M) | |
|---|---|---|---|---|---|---|---|---|
| | | Domestic | Export | Total | Sales Revenue | EBIT[1] | Revenue | EBIT |
| 2002/03 | 625 | 256 | 342 | 598 | 549 | 44 | 616 | 50 |
| 2003/04 | 614 | 261 | 325 | 586 | 560 | 59 | 637 | 67 |
| 2004/05 | 605 | 315 | 276 | 591 | 756 | 183 | 819 | 198 |
| 2005/06 | 591 | 278 | 300 | 578 | 709 | 107 | 794 | 120 |
| 2006/07 | 594 | 302 | 261 | 563 | 728 | 90 | 836 | 103 |
| 2007/08 | 605 | 300 | 277 | 577 | 725 | 93 | 846 | 108 |

[1] Earnings Before Interest and Tax

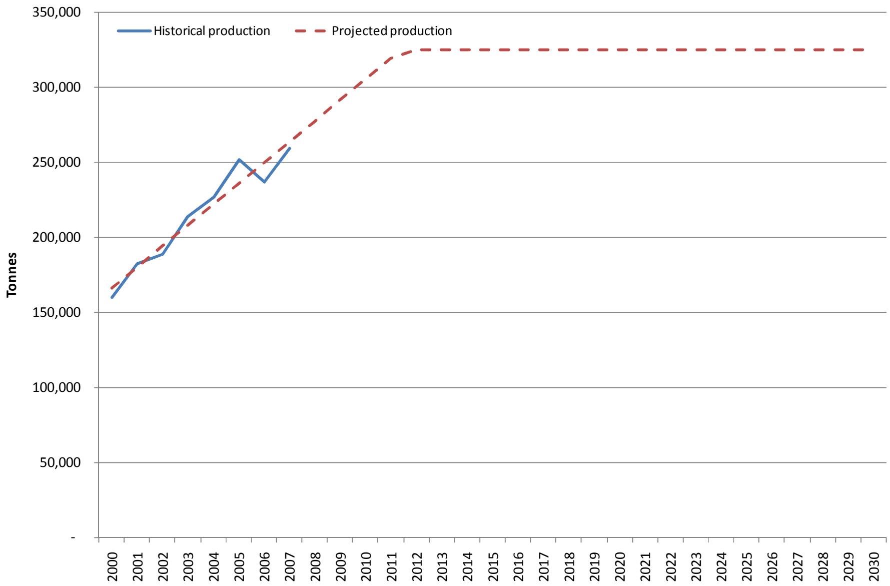
Source: Bluescope Steel Annual Reports; conversion to NZ$ uses exchange rates from www.oanda.com

### 3.2.2. Pacific Steel

Output from Pacific Steel's steel mill and rolling plant has been increasing over the last few years, with a small downturn in 2006. We use a simple projection of historical trends (linear regression) to project future plant output (Figure 9); output is constrained by the plant's capacity; the limit is set at 325,000 tonnes. [15]

[15] Hans Buwalda, personal communication

**Figure 9** Historical and Projected Future Steel Billet Production - Pacific Steel




## 3.3. Energy Intensity and Consumption

### 3.3.1. NZ Steel

Historical energy inputs to the Glenbrook steel mill are set out in Table 6. Coke is purchased in addition to coal; electricity is manufactured on site from the hot gases produced when the coal and iron sand are heated together to produce iron.

**Table 6** NZ Steel Energy Demand (Glenbrook & Waikato North Head)

| Year to June | Raw Steel Production | Coal | | Electricity | | | Gas | Coke | Diesel |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Grid | on-site | Total | | | |
| | Kt | Kt | PJ | GWh | GWh | GWh | TJ | tonnes | $m^3$ |
| 1999 | | 672 | 14.4 | 552 | 459 | 1,011 | 2,115 | 9,368 | 1427 |
| 2000 | | 717 | 15.4 | 501 | 501 | 1,001 | 1,966 | 12,912 | 1335 |
| 2001 | | 745 | 16 | 423 | 553 | 976 | 2,036 | 12,850 | 1397 |
| 2002 | | 691 | 14.9 | 402 | 518 | 920 | 2,008 | 8,933 | 1458 |
| 2003 | 625 | 810 | 17.4 | 396 | 636 | 1,032 | 2,139 | 4,405 | 1391 |
| 2004 | 614 | 786 | 16.9 | 432 | 587 | 1,019 | 1,953 | 6,258 | 1355 |
| 2005 | 605 | 808 | 17.4 | 460 | 587 | 1,047 | 1,969 | 7,359 | 1581 |
| 2006 | 591 | 818 | 17.6 | 423 | 597 | 1,020 | 2,063 | 6,158 | 1471 |
| 2007 | 594 | 791 | 17 | 435 | 584 | 1,020 | 2,045 | 4,505 | 1505 |

Source: NZ Steel

There are no strong trends in energy intensities of production; Figure 10 shows trends using indexes relative to 1999. Apart from coke, there is little obvious trend in energy intensity. We have simply used a five year average to derive energy intensities of production (Table 7).

**Figure 10** Energy intensity trends

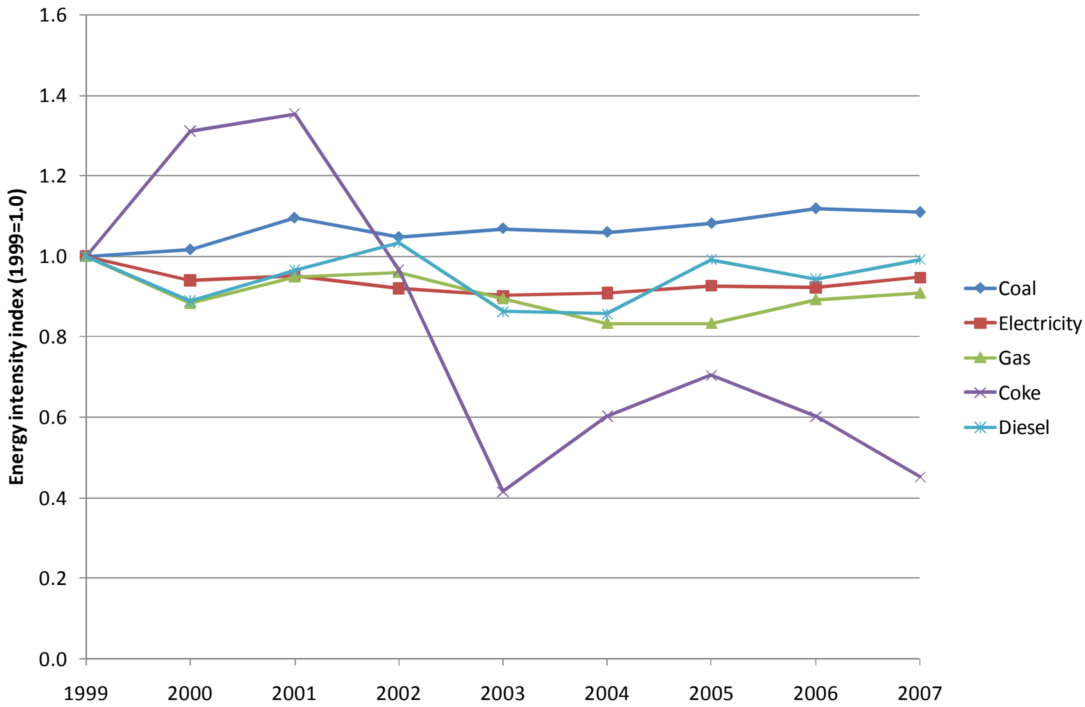



**Table 7** Energy intensities (per tonne of raw steel)

| Fuel | Coal | Electricity | Gas | Coke | Diesel |
|---|---|---|---|---|---|
| Unit | GJ/t | MWh/t | GJ/t | kg/t | l/t |
| Value | 28.5 | 1.70 | 3.4 | 9.5 | 2.4 |

Forward projections of energy consumption are based on these assumptions and these are shown in Table 8 along with direct $CO_2$ emissions in Table 9.

**Table 8** Projected annual energy consumption (NZ Steel)

| | Raw Steel Production | Coal | Electricity (in-house) | Electricity (grid) | Electricity (total) | Gas | Coke | Diesel |
|---|---|---|---|---|---|---|---|---|
| | kt | PJ | GWh | GWh | PJ | PJ | PJ | PJ |
| 2008 | 605 | 17.2 | 600 | 426 | 3.7 | 2.0 | 0.18 | 0.05 |
| 2009 | 610 | 17.4 | 600 | 435 | 3.7 | 2.0 | 0.18 | 0.05 |
| 2010 | 615 | 17.5 | 600 | 443 | 3.8 | 2.1 | 0.18 | 0.06 |
| 2015 | 640 | 18.2 | 600 | 486 | 3.9 | 2.1 | 0.19 | 0.06 |
| 2020 | 640 | 18.2 | 600 | 486 | 3.9 | 2.1 | 0.19 | 0.06 |
| 2025 | 640 | 18.2 | 600 | 486 | 3.9 | 2.1 | 0.19 | 0.06 |
| 2030 | 640 | 18.2 | 600 | 486 | 3.9 | 2.1 | 0.19 | 0.06 |
| 2035 | 640 | 18.2 | 600 | 486 | 3.9 | 2.1 | 0.19 | 0.06 |

**Table 9** Projected Direct $CO_2$ Emissions ('000 tonnes)

| Year | Coal | Gas | Coke | Diesel | Total |
|---|---|---|---|---|---|
| 2008 | 1,615.1 | 106.2 | 18.1 | 3.8 | 1,743 |
| 2009 | 1,628.5 | 107.1 | 18.3 | 3.8 | 1,758 |
| 2010 | 1,641.8 | 108.0 | 18.4 | 3.8 | 1,772 |
| 2015 | 1,708.6 | 112.4 | 19.2 | 4.0 | 1,844 |
| 2020 | 1,708.6 | 112.4 | 19.2 | 4.0 | 1,844 |
| 2025 | 1,708.6 | 112.4 | 19.2 | 4.0 | 1,844 |
| 2030 | 1,708.6 | 112.4 | 19.2 | 4.0 | 1,844 |
| 2035 | 1,708.6 | 112.4 | 19.2 | 4.0 | 1,844 |

### 3.3.2. Pacific Steel

Pacific Steel consists of two plants:

- a steel plant in which scrap steel is melted using an electric arc furnace to produce steel billet; and
- a rolling plant that heats the billet using gas and rolls it to produce rods and bars.

Rolled products are sold in New Zealand largely as input to the construction industry as mesh for use in concrete, columns and in pre-cast concrete. Small amounts are used to make wire and nails.

The previous report included energy use in the steel plant alone. In this report we expand the analysis to include the rolling plant also.

Historical energy use data are shown in Table 10. Using these data, we develop a number of energy and emission intensities of production that are used in assessing future energy use. These intensities are shown in Table 10.

**Table 10** Historical Production and Energy Use – Pacific Steel

| | Billet production | Electricity (GWh) | | | Gas | Diesel | Process $CO_2$ |
|---|---|---|---|---|---|---|---|
| | (tonnes) | Steel mill | Rolling mill | Total | (GJ) | (GJ) | (tonnes) |
| 2000 | 159,728 | 106 | 29 | 134 | 334,490 | 5,724 | 13,616 |
| 2001 | 182,105 | 110 | 29 | 139 | 321,320 | 6,051 | 17,854 |
| 2002 | 188,824 | 124 | 29 | 153 | 322,024 | 8,049 | 14,876 |
| 2003 | 213,503 | 126 | 29 | 155 | 336,481 | 7,672 | 9,959 |
| 2004 | 226,731 | 137 | 32 | 169 | 375,791 | 7,804 | 10,021 |
| 2005 | 251,713 | 141 | 31 | 172 | 349,738 | 9,375 | 10,060 |
| 2006 | 236,552 | 131 | 34 | 165 | 359,744 | 8,970 | 10,397 |

Source: Fletcher Building Ltd

There is a downward trend in electricity and gas energy intensities (Figure 11) with average compounding improvement rates of 3% and 5% per annum respectively. We would not expect these trends to continue throughout the forecast period (to 2035) but that there would be some ongoing improvements. Our assumptions are set out in Table 11.

**Figure 11** Energy intensity trends (Pacific Steel)

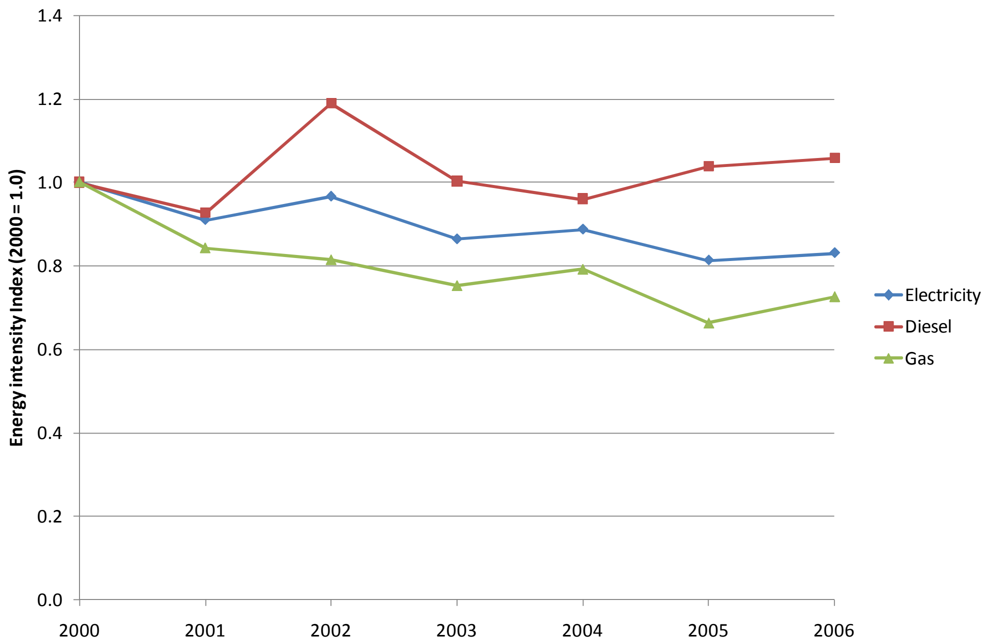



**Table 11** Energy Intensities – Pacific Steel

| Year | Annual intensity improvement (electricity & gas) | Electricity (kWh/t) | Diesel (GJ/t) | Natural gas (GJ/t) |
|---|---|---|---|---|
| 2006 | | 698 | 0.038 | 1.521 |
| 2007 | 3.00% | 677 | 0.038 | 1.48 |
| 2008 | 2.75% | 659 | 0.038 | 1.43 |
| 2009 | 2.50% | 642 | 0.038 | 1.40 |
| 2010 | 2.25% | 628 | 0.038 | 1.37 |
| 2011 | 2.00% | 615 | 0.038 | 1.34 |
| 2012 | 1.75% | 605 | 0.038 | 1.32 |
| 2013 | 1.50% | 596 | 0.038 | 1.30 |
| 2014 | 1.25% | 588 | 0.038 | 1.28 |
| 2015 | 1.00% | 582 | 0.038 | 1.27 |
| 2016 | 0.75% | 578 | 0.038 | 1.26 |
| 2017 | 0.50% | 575 | 0.038 | 1.25 |
| 2018 | 0.25% | 574 | 0.038 | 1.25 |
| 2019-2035 | 0.00% | 574 | 0.038 | 1.25 |

*Energy Projections*

We use these data to project future energy use at the plant(s).

**Table 12** Energy Demand – Pacific Steel

| Year | Production (kt) | Electricity GWh | Electricity GJ | Gas GJ | Diesel GJ | $CO_2$ Process | $CO_2$ Energy | $CO_2$ Total |
|---|---|---|---|---|---|---|---|---|
| 2007 | 264 | 181 | 652,269 | 394,516 | 9,837 | 11,402 | 21,230 | 32,632 |
| 2008 | 278 | 194 | 698,000 | 422,175 | 10,527 | 12,201 | 22,719 | 34,920 |
| 2009 | 292 | 204 | 733,080 | 443,393 | 11,056 | 12,815 | 23,860 | 36,675 |
| 2010 | 306 | 213 | 768,159 | 464,610 | 11,585 | 13,428 | 25,002 | 38,430 |
| 2011 | 319 | 223 | 803,239 | 485,828 | 12,114 | 14,041 | 26,144 | 40,185 |
| 2012 | 325 | 227 | 817,169 | 494,253 | 12,324 | 14,284 | 26,597 | 40,882 |
| 2015 | 325 | 189 | 681,180 | 412,002 | 12,324 | 14,284 | 22,312 | 36,596 |
| 2020-2035 | 325 | 186 | 671,009 | 405,850 | 12,324 | 14,284 | 21,991 | 36,276 |

## 3.4. Cut-Off Prices

We estimate the impacts of a number of factors on the value of NZ Steel's output. Revenues, costs and resulting EBITs are shown in Table 13. We have not been able to obtain cost data at sufficient detail to undertake the same analysis for Pacific Steel.

**Table 13** NZ Steel Financial Performance

| Year | Costs ($ million) | Revenue ($ million) | EBIT ($ million) | Costs ($/tonne) | Revenue ($/tonne) | EBIT ($/tonne) |
|---|---|---|---|---|---|---|
| 2002/03 | 566 | 616 | 50 | 906 | 986 | 80 |
| 2003/04 | 570 | 637 | 67 | 928 | 1,037 | 109 |
| 2004/05 | 621 | 819 | 198 | 1,026 | 1,354 | 327 |
| 2005/06 | 674 | 794 | 120 | 1,140 | 1,343 | 203 |
| 2006/07 | 733 | 836 | 103 | 1,234 | 1,407 | 173 |
| 2007/08 | 738 | 846 | 108 | 1,220 | 1,398 | 179 |

In addition to positive EBIT, a return on new capital spend will be required to ensure ongoing production at Glenbrook.[16] Net returns on assets (pre-tax) for the last three years have been 32% (year to June 2006), 24% (2007), 24% (2008).[17] It is unclear what the desired level of return is, but across the Bluescope Steel consolidated accounts there was a net return of 15.9% on assets in the 2007/08 year, a financial performance that was described by the Chairman as "an excellent one for BlueScope Steel."[18] Conservatively we might assume that an acceptable return is 15%. Annual capital spend is in the order of A$40 million which would suggest that they would need an annual profit of at least A$40 million plus 15%, ie A$46 million in total, close to NZ$58 million at current exchange rates. Below we address the factors that might affect such a change in net returns. EBITs over the last six years have average NZ$108 million, which would suggest that the plant might be at risk from additional costs of $50 million.

[16] We assume that a zero return on existing assets will not lead to closure as the costs are sunk. There will be a small required return on any residual value, eg as scrap, but the chief concern is with returns on additional capital spend.

[17] Bluescope Steel Annual Reports

[18] 2007/08 Annual Report

The most likely causes of changes in circumstances, in the absence of a carbon price, are increases in energy costs, changes in exchange rates or changes in commodity prices.

### 3.4.1. Energy Costs

Energy costs for NZ Steel are approximately NZ$194 million (Table 14). They use about 17.2PJ of coal and this costs $103million at $6/GJ. The other major energy cost is electricity (approximately $72 million).

**Table 14** NZ Steel Energy Costs

| Component | Value | Unit | Total | Unit | Unit Cost | Unit | Total ($M) | $/tonne |
|---|---|---|---|---|---|---|---|---|
| Coal | 28.5 | GJ/t | 17.2 | PJ | 6 | $/GJ | 103.2 | 171 |
| Gas | 3.4 | GJ/t | 2 | PJ | 8 | $/GJ | 16 | 27 |
| Electricity (grid) | 1.73 | MWh/t | 425 | GWh | 85 | $/MWh | 36 | 61 |
| Electricity (in house) | | | 600 | GWh | 60 | $/MWh | 36 | 61 |
| Coke | 9.6 | kg/t | 5,760 | tonnes | 100 | $/t | 0.6 | 1 |
| Diesel | 2.5 | l/t | 1,500 | ‘000 litres | 1.2 | $/litre | 1.8 | 3 |
| Total | | | | | | | 194 | 324 |

A $1/GJ increase in coal prices increases costs by $17million and an increase of $10/MWh for the grid electricity would result in a cost increase in the order of $4-5 million.

### 3.4.2. Emission costs

Total direct emissions from NZ Steel are approximately 1.8 million tonnes (Table 9) and there will be additional emissions associated with the use of grid electricity. Taking the long term projected demand for grid electricity (486 GWh) and a range of electricity emission factors of 0.2 – 0.6t/MWh, would imply additional emissions for which it might bear a cost of 0.1 – 0.3 million tonnes.

At emission costs of $25 and $50/tonne, this would imply total additional costs of $50 to $100 million. Evan at $25/tonne, these costs would place the plant at risk of closure.

### 3.4.3. Exchange Rates

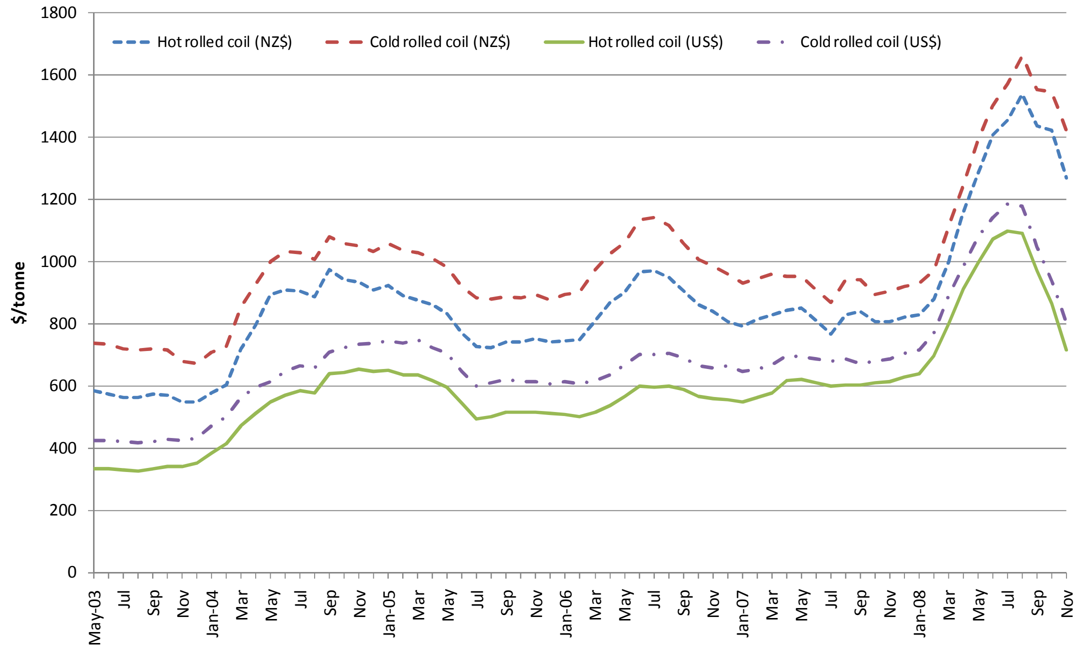
The recent movement in exchange rates is in NZ Steel’s favour. Revenues have been in the order of $1,000 - $1,500/tonne as an average of domestic and export sales over the last 5 years. Prices are set in US$, both in international and domestic markets; domestic market prices are set in US$ because NZ Steel products compete with imports. If we convert these NZ$ prices into the relevant US$ values, they range from approximately US$950 to US$1300/tonne. Previously NZSteel has noted that it receives approximately double the value for domestic sales versus exports, reflecting the higher value products and the costs of transport to New Zealand for imports.

Based on a revenue of US$1000/tonne a shift from an exchange rate of US0.75:NZ$ to one of 0.55 results in a change in revenue of NZ$485/tonne and a total change in revenue of $291 million.

### 3.4.4. Commodity prices

Figure 1 shows movements in steel prices over the last few years. These numbers are presented in US$ and converted into NZ$ using monthly average exchange rates.

**Figure 12** World steel prices




Source: MEPS International (www.meps.co.uk)

The current trend is down following a recent price spike. The average world price over the last financial year was approximately US$770/t as an average for hot and cold rolled steel, equivalent to NZ$1,000/t. NZ Steel received a higher amount, reflecting the mix of high value products in addition to basic rolled steel and the transport costs for competing imports; this is offset by transport costs to export markets. If we assume that the basic commodity price falls back to a historically typical US$600, this is $1,090/t at an exchange rate of 0.55 (and we could assume that NZ Steel maintains its average price advantage above this). Without the change in exchange rate the reduction would be a loss of revenue of approximately $370/t and a total cost of approximately $220 million.

### 3.4.5. Conclusion

NZ Steel is vulnerable largely to changes in exchange rates and commodity prices. Falls in commodity prices to historical levels would have had a significant impact on profits if exchange rates had been maintained at elevated levels. If the US$:NZ$ exchange rate was to remain at current rates the risks of NZ Steel's plant closure appear to be significantly diminished.

Direct greenhouse gas emissions are estimated at 1.96 million tonnes. If NZ Steel paid for all of its direct emissions,[19] this would be an annual cost of $49 million at an emissions cost of $25/tonne. Using the current EBIT estimates and ongoing capital cost

[19] And assuming that the $80/MWh electricity price estimate includes an emissions cost

requirements, this would be expected to lead to a running down of the Glenbrook plant with no additional capital expenditure and limited or no maintenance; or it could lead to a very swift closure with plant components sold.

However, the impacts could be mitigated by predicted growth in domestic demand which will result in a higher level of revenue and EBIT.

# 4. Cement and Lime Production

## 4.1. Cement Production

There are two producers of cement in New Zealand:

- Holcim (New Zealand) Ltd, that operates a cement plant in Westport; and
- Golden Bay Cement that operates a plant in Whangarei

There are a number of different types of cement, but the most common variety is Portland cement. It is a fine powder and binding material that hardens when mixed with water. Manufacture of Portland cement is a four step process: [20]

1. **Quarrying**—limestone and a 'cement rock' such as clay or shale are quarried to be used as the raw materials of cement manufacture. These rocks contain lime ($CaCO_3$), silica ($SiO_2$), alumina ($Al_2O_3$) and ferrous oxide ($Fe_2O_3$) -
2. **Raw material preparation**—to form a consistent product, the same mixture of minerals is used every time. The exact composition of the limestone and clay is determined, other ingredients added if necessary and the rock is ground into fine particles to increase the efficiency of the reaction. There are two different approaches used in New Zealand
   a. **The dry process,** used by Golden Bay Cement, in which the quarried clay and limestone are crushed separately until nothing bigger than a tennis ball remains. The clay and limestone, plus any other added materials, are then fed together into a mill where the rock is ground until more than 85% of the material is less than 90μm in diameter.
   b. **The wet process,** used by Holcim, in which the clay is mixed to a paste in a washmill - a tank in which the clay is pulverised in the presence of water. Crushed lime is then added and the whole mixture further ground. Any material which is too coarse is extracted and reground. The slurry is then tested to ensure that it contains the correct balance of minerals, and any extra ingredients blended in as necessary.

3. **Clinkering**—the raw materials are dried, heated and fed into a rotating kiln along with pulverised coal. They react at very high temperatures and agglomerate to form 'balls' of cementitious material (calcium silicates plus aluminium- and iron-containing compounds) known as clinker.[21]

4. **Cement milling**—the clinker will behave just like cement, but it is in particles up to 3 cm in diameter. The particles are mixed with gypsum and ground down to a fine powder to turn the clinker into useful cement.

---

[20] NZ Institute of Chemistry. The Manufacture of Portland Cement. (www.nzic.org.nz/ChemProcesses/inorganic/9B.pdf)

[21] It comprises a mixture of $3CaOSiO_2$ (tricalcium silicate), $2CaOSiO_2$ (dicalcium silicate), $3CaOAl_2O_3$ (tricalcium aluminate) and $4CaOAl_2O_3Fe_2O_3$ (tetracalcium alumino-ferrate)

The clinkering stage is the most energy intensive and it differs between the dry and wet processes:[22]

- In the dry process, the powder is dried in a pre-heated tower. As it falls through the tower it is heated from 70°C to 800°C; moisture evaporates and up to 20% of the process $CO_2$ emissions occur during this pre-clinkering stage. The mixture is then fed into the kiln where the remaining process $CO_2$ emissions are emitted.
- In the wet process, there is no pre-heating; rather, the wet slurry is fed directly into the kiln where it forms into dry balls. Because of the need to evaporate more water, the kiln is larger and the process is longer than for the dry process.

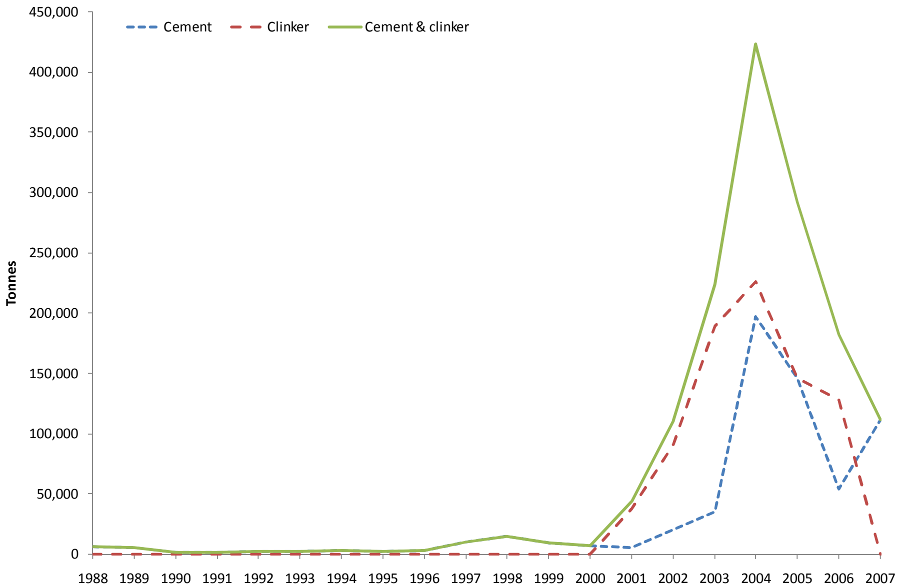
In both processes the kilns are heated by injecting pulverised coal dust into the discharge end where it spontaneously combusts.

Following the kiln, there is a large cooler designed to drop the temperature of the clinker from 1000°C to 150°C. Air is forced through a bed of clinker through perforated plates.

## 4.2. Cement Markets

New Zealand cement plants meet domestic demand for cement. In recent years, demand has outstripped supply and substantial amounts of cement have been imported (Figure 13). Import peaks have included periods in which there have been plant closures, including for a major upgrade at Golden Bay Cement.

**Figure 13** Cement and Clinker Imports




Source: Statistics New Zealand. Infos Time Series Output

Total demand has increased in response to increasing construction activity. Going forward, levels of production in New Zealand will not necessarily increase with

[22] NZ Institute of Chemistry (op cit)

demand, because of the option for product imports. Our projections of energy demand and emissions are based on estimates of current and expected future plant capacity.

## 4.3. Holcim

### 4.3.1. Production

Holcim's Westport cement plant employs a wet process technology to manufacture approximately 500,000 tonnes of cement per annum (Figure 14).

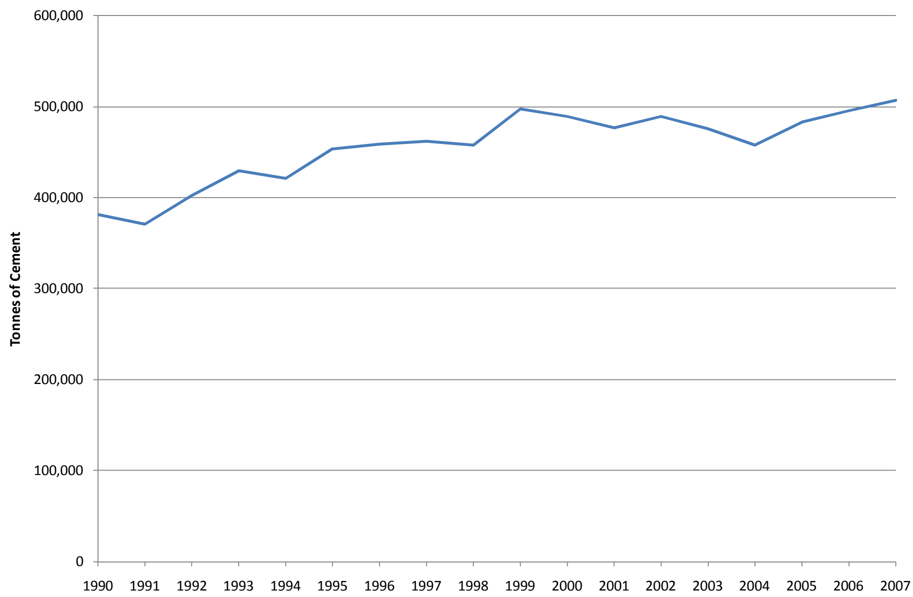
### 4.3.2. Energy Intensity

The energy used in clinker production includes coal and waste oil. Based on recent trends in consumption (summarised as the intensities in Figure 15) the assumed energy intensities are shown in Table 15. Electricity is used in cement manufacture from clinker; the electricity intensity over time is shown in Figure 16. This is used to produce an assumed electricity intensity of 0.1MWh/tonne of cement.

**Table 15** Future Energy Intensity of Cement and Clinker Production – Holcim Westport

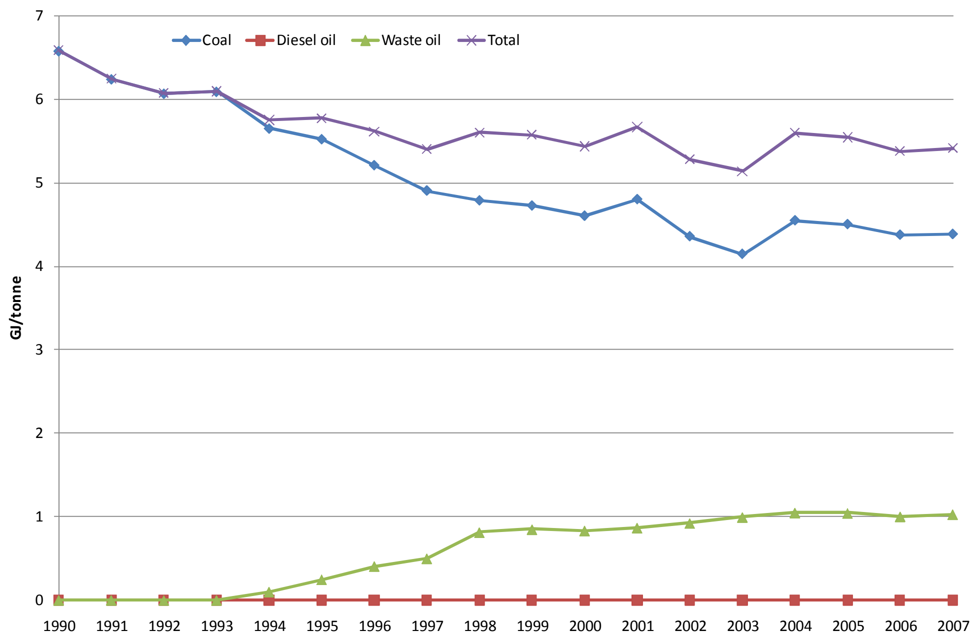
| Fuel | Intensity (GJ/t clinker) | Intensity (GJ/t cement) |
|---|---|---|
| **Clinker** | | |
| Coal | 4.9 | 4.4 |
| Waste oil | 1.1 | 1.0 |
| Diesel oil | <0.01 | <0.01 |
| Total | 6.0 | 5.4 |
| **Cement** | | |
| Electricity | | 0.1 MWh/t |

**Figure 14** Cement Production - Holcim Plant



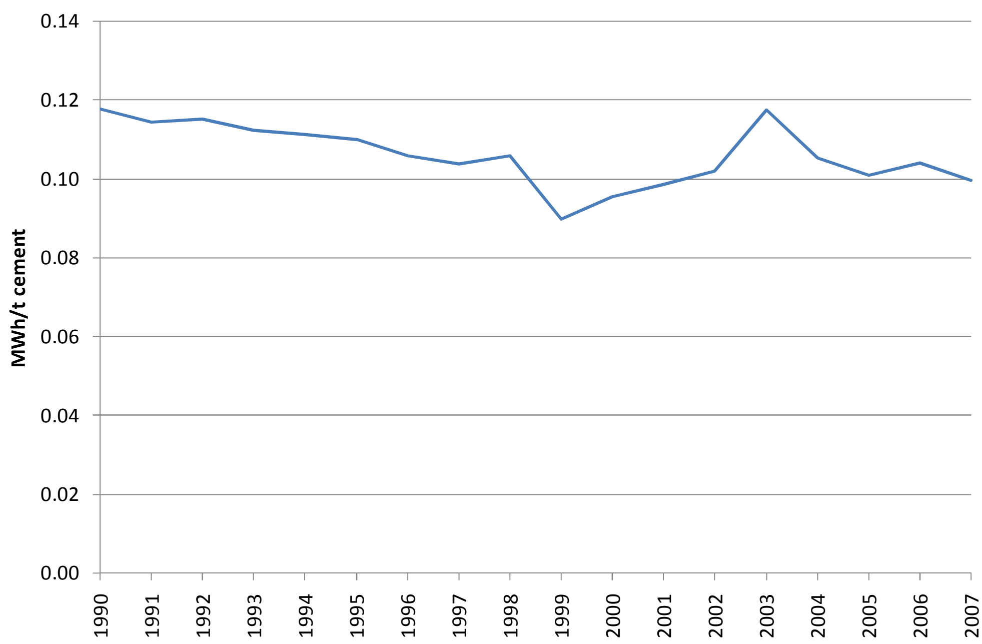

Source: Holcim

**Figure 15** Energy Intensity Clinker Production - Holcim Plant




Source: Holcim

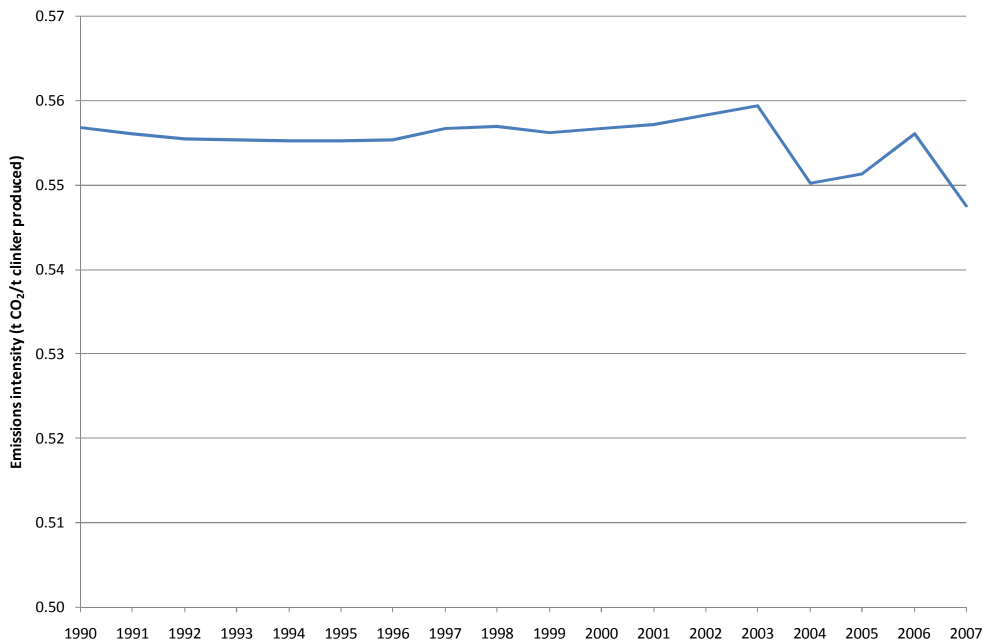
**Figure 16** Electricity Intensity Cement Production - Holcim Plant




### 4.3.3. Greenhouse Gas Emissions Intensity

In addition to emissions from the combustion of fossil fuels, there are emissions from the chemical process also. The historical emissions intensity is shown in Figure 15. We assume 0.55t $CO_2$ per tonne of clinker as a forward projection.

**Figure 17** Process Emissions Intensity - Holcim Plant




### 4.3.4. Total Energy Use and Emissions

Estimated energy consumption and total emissions are shown in Table 16 based on estimated production of 500,000 tonnes of cement, which is the approximate capacity of the plant. We assume that these are constant over time if the Westport plant continues in operation. Currently an alternative, larger plant is being considered (see below); if the new plant was built, the existing plant would close.

**Table 16** Total Energy Use and Emissions – Holcim Existing Plant

| | Kiln Energy | | | Equipment & on-site vehicles | | Electricity | Process emissions | Total |
|---|---|---|---|---|---|---|---|---|
| | Coal | Diesel oil | Waste oil | Diesel oil | Petrol | | | |
| TJ | 2,200 | 1.7 | 500 | 36.3 | 0.2 | 180 | | 2,918 |
| t $CO_2$ | 195,360 | 111 | 36,850 | 2,683 | 13 | | 249,649 | 484,682 |

We have assumed no improvement in energy efficiency reflecting the slowing down of the rate of improvement in energy efficiency as shown in Figure 15 above.

### 4.3.5. New Plant

Holcim has announced that it is examining options for a new plant; chief amongst these is a site at Weston near Oamaru. It would be larger (an output capacity of 880,000 tonnes of cement) and more efficient; it would use a dry production process. Currently demand for cement in New Zealand is greater than levels of domestic supply such that some demand is met by imports; this new plant would enable Holcim to meet more of the domestic demand for cement. The improved energy efficiency of the plant would reduce variable production costs and this is a strong motivator for the new investment. However, concerns over the way in which the plant would be treated under the emissions trading system are resulting in some uncertainty. This is particularly over eligibility for gratis allocation of emission units and, if the existing plant is deemed eligible, if the eligibility (and number of units) would transfer to the new plant.

Our assumptions on the total energy use and emissions from the proposed new plant are given in Table 17.

**Table 17** Total Energy Use and Emissions – Holcim New Plant

| | Kiln Energy | | | Equipment & on-site vehicles | | Electricity | Process emissions | Total |
|---|---|---|---|---|---|---|---|---|
| | Coal | Diesel oil | Waste oil | Diesel oil | Petrol | | Tonnes | |
| GJ/t | 2.83 | <0.01 | 0.64 | | | | | |
| TJ | 2,488 | 1.9 | 565 | 41.0 | 0.2 | 317 | | 3,413 |
| t $CO_2$ | 220,938 | 143 | 41,675 | 3,034 | 15 | | 399,439 | 665,243 |

## 4.4. Golden Bay Cement

The Golden Bay Cement plant is located in Portland, near Whangarei, Northland. The plant has been in operation since c1920 using local limestone. Limestone is now extracted from a quarry adjacent to the plant and another (with higher grade limestone) north of Whangarei.

Other inputs to the plant include gypsum, imported from South Australia.

### 4.4.1. Production and Energy Use

Production levels at the 900,000 tonne capacity plant in 2007 are shown in Table 18. Energy used in production is shown in Table 19. These are for a single year (calendar year 2007) but this followed a major plant upgrade such that previous years' data are not applicable for developing future projections.

**Table 18** Golden Bay Cement Production

| Product | Tonnes |
|---|---|
| Clinker | 809,047 |
| Cement | 861,108 |

Source: FBL

**Table 19** Golden Bay Cement 2007 Energy Use

| Fuel | Quantity | Conversion factor | TJ |
|---|---|---|---|
| Coal | 93,361 tonnes | 27.0 MJ/kg | 2,521 |
| Woodwaste | 34,062 green tonnes | 9.33 MJ/kg | 318 |
| Diesel | 1,199,347 litres | 38.36 MJ/litre | 46 |
| Electricity | 101,687 MWh | 3.6 GJ/MWh | 366 |
| Total | | | 3,251 |

For future projections, we assume production of 880,000 tonnes of cement (826,797 tonnes of clinker) and energy consumption data as shown in Table 20.

**Table 20** Golden Bay Cement Projected Energy Use

| Fuel | Quantity | TJ |
|---|---|---|
| Coal | 80,578[1] tonnes | 2,176 |
| Woodwaste | 77,728 green tonnes | 725 |
| Diesel | 1,225,660 litres | 47 |
| Electricity | 103,918 MWh | 374 |
| Total | | 3,322 |

[1] This assumes some substitution of coal for wood waste, compared to historical fuel use

### 4.4.2. $CO_2$ Emissions

Process emissions of $CO_2$ and emissions from energy consumption are shown in Table 21.

**Table 21** Golden Bay Cement $CO_2$ Emissions

| Source | 2007 emissions (tonnes) | t/t clinker | Projection (tonnes) |
|---|---|---|---|
| Process Emissions | 436,885 | 0.54 | 446,470 |
| Energy | | | |
| Coal | 223,842 | 0.28 | 228,753 |
| Woodwaste | 0 | 0.00 | 0 |
| Diesel | 3,405 | 0.004 | 3,479 |
| Total | 664,132 | 0.78 | 678,702 |

## 4.5. Vulnerability to Price Changes

Cement production is energy and emissions intensive, particularly the production of clinker as an intermediate product. The cement manufacturers have not made production cost or other financial information available to this study and it is not possible to extract the cement manufacturing cost information from consolidated company accounts that include several products. However, the key vulnerabilities are to:

- Carbon prices that would increase manufacturing costs in New Zealand and could lead to imports of finished product or clinker for milling in New Zealand.
- Increases in energy costs, particularly coal and electricity, would have the same effect.
- Exchange rate movements—cement is priced against US$ prices but costs are set in NZ$s. This means that falls in the value of the NZ$ lead to a higher cost of importing and improve profitability of manufacture in New Zealand.

The landed price of imported bulk Portland cement to New Zealand is approximately $190/tonne. Emissions from cement manufacture are approximately 1.0t $CO_2$/t cement for Holcim's old plant but approximately 0.76t/t for its new plant and 0.77t/t for GBC's plant. At emissions costs of $25/tonne and $50/tonne, and a mid-point 0.765t $CO_2$/tonne of cement, this is a cost of $19 or $38/tonne respectively, which is 10% or 20% of the value of the output. This is a significant impact. Electricity price impacts would be additional to this.

## 4.6. Total Energy Use

Projections of future energy use are based on the assumptions noted above. We assume that there is no additional improvement in energy or emissions intensity and that there are static levels of production with imbalances between supply and demand balanced by imports and/or exports. Projected total energy use and emissions are shown in Table 22.

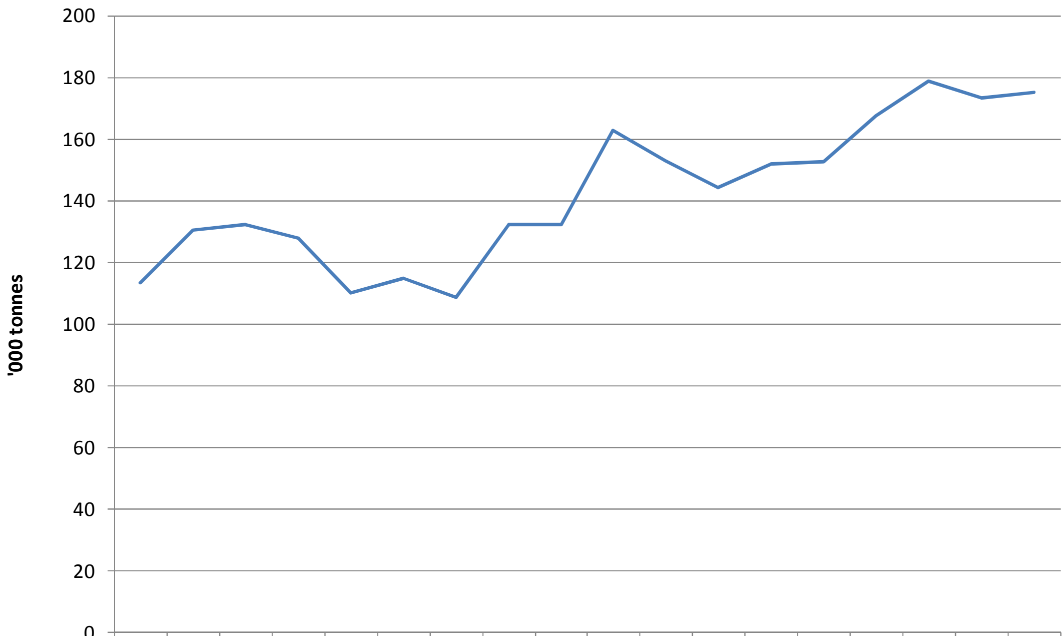
**Table 22** Aggregate Annual Cement Energy Use and $CO_2$ Emissions

| | Holcim Old | Holcim New | GBC | Total (Old) | Total (New) |
|---|---|---|---|---|---|
| Production (kt) | 500 | 880 | 880 | 1,380 | 1,760 |
| Coal | 2,200 | 2,488 | 2,176 | 4,376 | 4,664 |
| Diesel | 38 | 43 | 47 | 85 | 90 |
| Waste oil | 500 | 565 | | 500 | 565 |
| Woodwaste | | | 725 | 725 | 725 |
| Electricity (MWh) | 50,000 | 88,000 | 103,918 | 153,918 | 191,918 |
| Electricity (TJ) | 180 | 317 | 374 | 554 | 691 |
| **Total (TJ)** | **2,918** | **3,413** | **3,322** | **6,240** | **6,735** |
| Process $CO_2$ | 249,649 | 399,439 | 446,470 | 696,119 | 845,909 |
| Energy $CO_2$ | 235,032 | 265,804 | 232,232 | 467,265 | 498,037 |
| **Total $CO_2$** | **484,682** | **665,243** | **678,702** | **1,163,384** | **1,343,945** |

## 4.7. Lime

Three companies produce burnt lime in New Zealand. The process is similar to that for the manufacture of cement but does not involve the addition of other materials. It involves the heating of limestone to produce calcium oxide. Total production is estimated from data in the greenhouse gas inventory, taking account of total process emissions and the emissions factor. The resulting production data are shown in Figure 18.

**Figure 18** Burnt lime production




| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| '000 tonnes | 113 | 130 | 132 | 128 | 110 | 115 | 109 | 132 | 132 | 163 | 153 | 144 | 152 | 153 | 167 | 179 | 173 | 175 |

Source: Estimated from MED (2008) New Zealand Energy greenhouse Gas Emissions 1990-2007

We have estimated energy use and emissions on the basis of data provided by Holcim Ltd. These have been scaled up to total New Zealand production. We have included energy use associated with the production of lime from limestone, ie the kiln process, and excluded energy use associated with quarrying of limestone that would provide lime for agricultural purposes in addition to burnt lime production.

**Table 23** Burnt lime production - energy and emissions intensities

| | Energy intensity | | Emissions intensity | |
|---|---|---|---|---|
| Diesel | MJ/t | 28.5 | kg $CO_2$/GJ | 69.5 |
| Petrol | MJ/t | 0.4 | kg $CO_2$/GJ | 66.2 |
| Natural gas | GJ/t | 0.1 | kg $CO_2$/GJ | 52.4 |
| Coal | GJ/t | 7.9 | kg $CO_2$/GJ | 91.2 |
| Electricity | MWh/t | 0.04 | | |
| Industrial process emissions | | | t/t | 0.79 |

Holcim suggests that there is no expected increase in plant capacities in New Zealand. We project energy demand and emissions going forward on the basis of a static estimate of 180,000 tonnes of burnt lime produced.

**Table 24** Burnt lime production - energy and emissions projections

| | Energy consumption | | Emissions (t $CO_2$) |
|---|---|---|---|
| Diesel | GJ | 5,134 | 357 |
| Petrol | GJ | 68 | 5 |
| Natural gas | GJ | 17,792 | 932 |
| Coal | GJ | 1,429,693 | 130,388 |
| Electricity | MWh | 7,337 | |
| Industrial process emissions | | | 142,200 |
| Total emissions | | | 273,881 |

# 5. Petrochemicals

## 5.1. Description

Petrochemical production in New Zealand includes methanol and fertiliser production. There have been three major petrochemical plants in New Zealand all based in Taranaki using natural gas as a feedstock. Methanex New Zealand owns two methanol plants, one at Waitara valley and the other, the former synthetic fuel plant at Motunui. Ballance Agri-Nutrients (Ballance) has a plant in Kapuni making ammonia and urea from natural gas.

### 5.1.1. Methanol

The Taranaki methanol plants are significant by international standards with the capacity to produce 10% of the world's methanol demand. Early this decade the Motunui plant was closed while the Waitara plant was used as a flexible supply, responding to changes in input and output prices. With improved gas supply half of the Motunui plant has been reopened with the Waitara plant available if more gas feedstock is secured.

The methanol production process converts natural gas through a series of steps (reforming, compression, synthesis and distillation) to distilled methanol suitable for export to world markets. At capacity, 98% of the Taranaki production is exported to the Asia-Pacific region. Some of the energy in the natural gas is used during the process of conversion (approximately 55 to 60% of the initial energy is retained in the methanol). In addition the plant requires some electricity input.

The Motunui complex is actually two separate methanol trains each producing about 2,500 tonnes/day. At the time they were opened, they were the largest single site methanol plants in the world. The Waitara valley plant is a smaller single train unit of about 1,400 tonne/day.

Methanex is a Canadian based company and is the world's largest producer of distilled methanol.  Methanol is a global commodity that is routinely traded in international markets.

All the petrochemical plants were built in the 1980s as part of the 'Think Big' projects of that era. They were proposed as a way for the Government to use the Maui gas it was obliged to take under the Maui take or pay agreement. The Waitara valley plant was always designed to make export methanol. However the Motunui plant used methanol as an intermediate step to produce synthetic petrol and reduce New Zealand's import dependence on liquid fuels.

With decreasing oil prices in the late 1980s and early 1990s it became more profitable to produce methanol rather than petrol. Methanol distillation was added to produce export grade methanol and gradually the proportion of methanol production increased and petrol decreased. By 1998 all production was switched to methanol.

With the reduction in gas availability from the 2003/2004 Maui field redetermination, Methanex found that it had fully used its Maui gas entitlement. It has since secured some gas from other sources including some additional gas from Maui. This is enabling the Waitara plant to operate flexibly, but the Motunui plant shutdown until further notice in November 2004.

In recent years prices for methanol have improved along with more availability of gas in New Zealand. As a result since 2006, the Waitara valley plant has run close to full capacity (between 80 and 85% based on methanol produced versus nominal 500,000 tonne capacity) and more recently Methanex announced that they are going to reopen one train of the Motunui plant[23]. One train at the Motunui plant can process up to 34PJ of gas (to produce approx. 900,000 tonnes of methanol) rather than the maximum of 20PJ at Waitara. Methanex plans to shut down Waitara plant once the Motunui plant is up and running again although they will consider running both Motunui and Waitara if they can get enough gas[24].

### 5.1.2. Ammonia/Urea

Ballance is a New Zealand company involved in the development, manufacturing and marketing of fertilisers to the agriculture sector. Balance owns and operates New Zealand's only ammonia/urea plant at Kapuni in South Taranaki. The plant was first commissioned in 1982 and revamped in 1996, increasing capacity by 45%.

The plant takes natural gas, reforms it and then mixes it with air (nitrogen and oxygen). The carbon monoxide produced is then converted to carbon dioxide ($CO_2$) which is separated for use in urea production. The remaining gas (largely nitrogen and hydrogen) is compressed and then synthesised into ammonia ($NH_3$). A small amount of ammonia is sold directly but most is fed to the urea plant which combines it with $CO_2$ and then dries it to form a granulated urea ($CO(NH_2)_2$) ready for sale.

Like the methanol process the urea process uses some of the energy from the natural gas feedstock during the conversion process. Electricity is also a key input.

The critical issue for Ballance is securing continued gas supply at competitive prices. Balance notes in its 2004 Annual report that "the key issue is obtaining continuity of gas supplies at a price our customers will find acceptable relative to imported products…". However as with methanol, the outlook for fertiliser manufacture is now much more positive than it was in 2005.

Ballance's has a gas supply agreement that runs through to June 2010[25] and strong fertiliser prices are resulting in good profits. They have continued to run at capacity

---

[23] The Motunui plant is two methanol trains. Only one methanol train is being reopened so the statistics given relate to that one train.

[24] Methanex press release: www.scoop.co.nz/stories/BU0805/S00231.htm

[25] Balance media release 30 October 2006

(around 7PJ gas use per year) with small variations, probably as a result of maintenance shutdowns.

Because of the shortage of gas, both Ballance and Methanex moved into the upstream sector in 2004/2005 supporting exploration activity in an attempt to find more gas supplies[26]. Neither company has had any significant success with their exploration efforts.

## 5.2. Domestic and International Markets

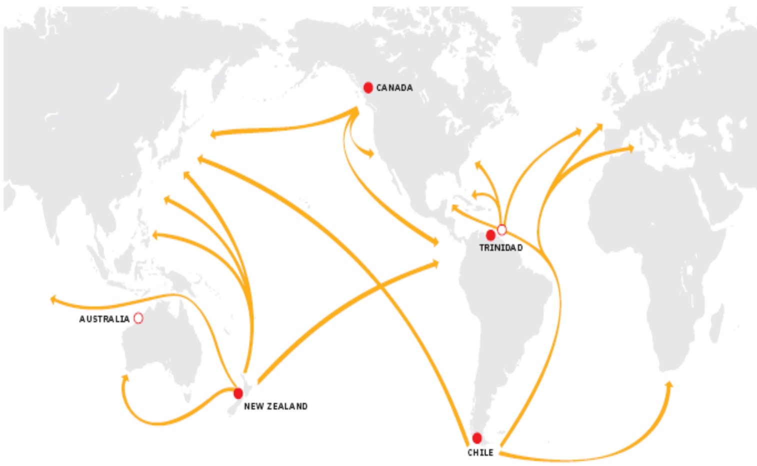
### 5.2.1. The Markets

*Methanol*

Methanol is an international commodity produced worldwide from a standard process using natural gas. Methanol's primary uses are as a feedstock to the chemical industry. It is occasionally used directly as a fuel and is being investigated as a suitable fuel source for onboard reforming in the use of fuel cell vehicles.

There is a growing worldwide demand for methanol but production is shifting to lower cost countries such as Trinidad or Chile. Many of the older methanol plants in developed countries (especially USA and Canada) have been closed despite their proximity to markets. Figure 19 shows the global methanol flows for Methanex, the world's largest producer.

**Figure 19** Methanex Global Methanol Flows




Source: www.methanex.com

The key to shifting production to lower cost countries is the price of natural gas, the key feedstock for making methanol. In developed countries, such as the US, there are many competing uses for natural gas such as direct domestic and industrial use and for

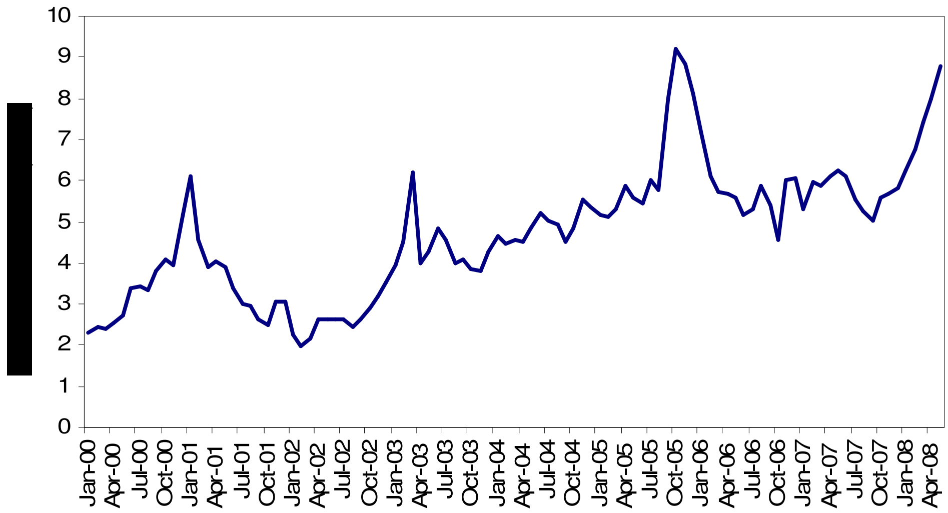
[26] http://www.energyreview.net/storyview.asp?storyid=42159&sectionsource=s90&highlight=Methanex

electricity generation. Figure 20 shows the recent trend in natural gas prices in the US. Prices are now (August 2008) high due to high demand relative to local supply, driven by high value use with limited flexibility to switch to alternative fuels. Pre 2000, when there was a gas surplus, the price varied between US$1.25-2.50/GJ.

At these prices, methanol producers in countries such as the US struggle to compete. Most worldwide production capacity built early this decade has been sited close to major gas fields where gas prices would be closer to US$1/GJ[27]. A methanol plant is a way of monetising gas fields which are remote from large industrial or domestic demand. The requirement to monetise the Maui gas asset was a driver for the development of methanol plants in New Zealand. However whereas Maui contract gas was priced between US$1.00-1.50/GJ[28], the current New Zealand gas price is over US$4/GJ (NZ$6/GJ)[29].

In recent years the run up in oil prices has seen a large expansion in LNG developments to meet demand for natural gas. These large scale LNG developments compete with methanol production for low cost gas which has the effect of driving the cost of that gas up. At the same time, some major plants (such as Methanex's Chile plant) have found their gas supply substantially cut because of pressure from other uses.

**Figure 20** US Wellhead Natural Gas Prices




Source: US Energy Information Agency Monthly Energy Review

Delivered LNG prices have been noted at US$10-11/MMbtu (US$9.5-10.5/GJ) in the past year. While the cost of LNG plants has also escalated in the last few years (probably

---

[27] Figures of US$0.75/mmbtu (US$0.70/PJ) were commonly used in example economics for large methanol plants earlier this decade

[28] Until 2003

[29] "Exploring the Options for Gas Exploration Funding", Chris Stone, Gas Industry Reform Conference August 2004

tripling since 2003)[30], the increase in prices has fed back to the value of the gas resource. Whereas previously it was expected large scale methanol plants would be sited where the gas resource may have a value of US$1/GJ, these resources may be more than double that value now (>US$2/GJ).

The price paid by Methanex for gas in New Zealand is not known although some market commentators have estimated current prices between NZ$6 and $7/GJ (~US$4.50/GJ)[31]. The Energy Data File reports an average price for gas used in the petroleum, coal and chemical products sector which is shown in the table below along with the percentage petrochemicals (Methanol and Urea) is of that sector.

**Table 25** Average natural gas price for petroleum, coal and chemicals sector

| | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| Average Price (NZ$/GJ) | 3.16 | 2.89 | 3.70 | 5.77 | 5.93 |
| Petrochemical proportion | 98% | 98% | 89% | 83% | 76% |

Source: MED Energy Data File/ Hale & Twomey

This data shows the impact of increasing prices since the end of the Maui contract for petrochemicals but suggests that average prices for methanol production (as the biggest user) are still under NZ$6/GJ.

*Urea*

Urea is an internationally traded commodity that is purchased and imported through a number of New Zealand ports. The production in Taranaki needs to be competitive with these supplies. Urea is used primarily as a nitrogen rich fertiliser in the agricultural, horticultural and forestry sectors. It is also used as a feedstock in the industrial sector, the largest in New Zealand being the manufacture of urea formaldehyde resin used for making plywood, particleboard and similar products. Smaller uses include fibreglass, yeast making, livestock feed, pharmaceuticals, cosmetics and paint.

The use of urea in the agricultural sector has increased significantly in recent years with the improvement in agricultural profitability. Tonnes of urea used per year increased from around 20,000 tonnes in the 1980s to about 125,000 tonnes in the mid 1990s to between 300,000-450,000 tonnes in the last five years.[32] The expansion and profitability of the diary sector will be supporting this demand.

Production data shows that the Ballance Kapuni plant has continued to operate at capacity in recent years with imports meeting the balance of demand. If the Kapuni plant is uncompetitive, all supply could be imported from the international market. The only competitive advantage for the New Zealand plant is the saving of the freight required to get imported product to New Zealand.

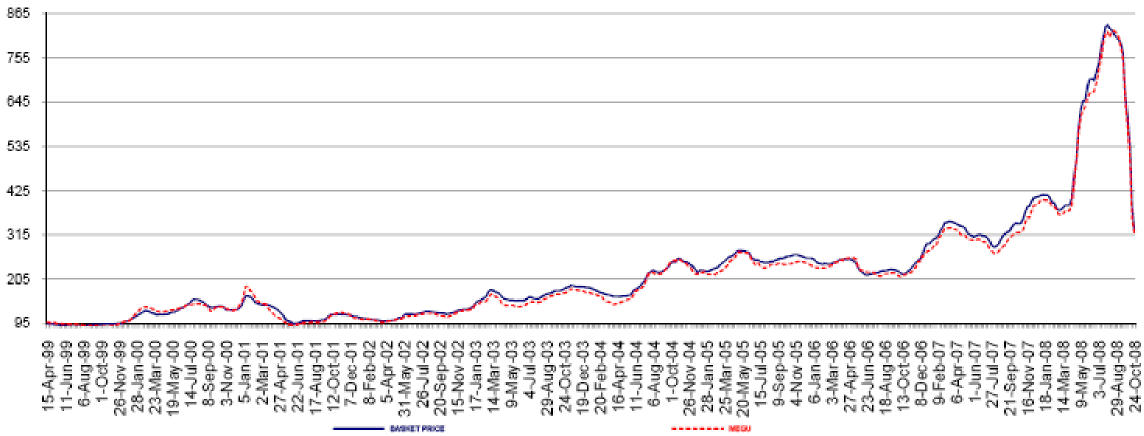
[30] Oil & Gas Journal Feb.25 2008.

[31] http://www.stuff.co.nz/4653370a13.html

[32] Ministry of Agriculture and Forestry

Like methanol, urea is a globalised business. Urea is another way of monetising low value or remote gas, and many of the large producers are in the Middle East where there is low cost gas. World trade in urea is 20-25 million tonnes annually.[33] Like many other commodities recent price changes have been driven by Chinese demand and increased worldwide demand for food. Prices in the 1990s were volatile as the industry expanded to meet higher demand. The resulting surplus capacity resulted in low prices. In the last few years prices for Urea have steadily increased as shown in the market benchmark price in Figure 21 with a very sharp spike in 2008 (driven higher in the commodity boom and very recently fallen in line with all commodities and markets).

**Figure 21** World Urea Prices (US$/tonne)




MEGU = Middle East Granular Urea

Source: http://www.fertilizerworks.com/html/market/BasketPrice.pdf (24 October 2008)

### 5.2.2. Drivers of Market Demand

*Methanol*

The key driver of methanol demand is industrial use as a feedstock. As demand for products produced by these plants (e.g. sports equipment, MDF plywood, paint and adhesives) grows, so demand for methanol increases. Methanex states that the methanol industry has had to build on average one world scale plant each year to meet increasing demand.

The decline of use of methanol in Methyl Tertiary Butyl Ether (MTBE) manufacture appears to be balanced by growth in other markets. MTBE is a high-octane component used for petrol blending. However there is environmental concern about the use of MTBE because of possible release into the ground as minute quantities can taint groundwater. Many states in the US have banned MTBE on these grounds, whereas Europe and much of Asia continue to use it, saying it is not an issue if the product is well managed.

Methanol is a key component of MTBE manufacture so where MTBE is banned methanol demand is affected. However Asia and Europe have not followed the US's position (note: Australia and New Zealand ban MTBE use in petrol).

---

[33] Source: www.fertilizerworks.com

A possible future use for methanol in fuel cells could significantly increase worldwide demand. Methanol is a very good hydrogen carrier and is a useful medium to fuel reformers that would produce hydrogen for fuel cell applications. These applications might be anything from mobile computers to vehicles.

Methanex reports that global demand remains healthy in traditional chemical derivatives and in energy applications. It is noted that China is using methanol for fuel blending and for dimethyl ether (DME).[34] This demand is driven by the general high energy prices.[35]

*Urea*

The market for urea is linked to the health of the agricultural sector and demand offshore for wood products using resins. With the continued expansion of dairying in New Zealand the outlook at the moment is for continued high demand. Demand in New Zealand would need to drop by greater than 50% before production from Kapuni would necessarily be affected.

A possibly greater threat to demand growth may come from the environmental effects of fertiliser application. With urea application, farmers aim to enhance the nitrogen levels of soil. However, especially with poor application, there is an element of the nitrogen which runs off the land into rivers and waterways through rain. The high nitrogen levels in the water have an adverse impact on water quality. While these concerns are increasing, there appears to be no impact on demand to date. The 2008 spike in prices is likely to have a bigger short term impact on demand.

### 5.2.3. Trends in Commodity Prices

*Methanol*

Historically methanol prices have cycled reflecting the balance between supply and demand. High prices, when capacity is highly utilised, have encouraged new investment which, because of their lumpiness, lead to a product surplus and a price fall. As a capital intensive industry, once the capital is committed (plant is built) cash cost is relatively low and often there are natural gas off-take commitments that require a plant to be run. During this decade there has been a general increase in prices (shown in Figure 22) with increased volatility in the last three years. For much of the 1990s (and as recently as mid 2001) prices were below US$150/tonne.

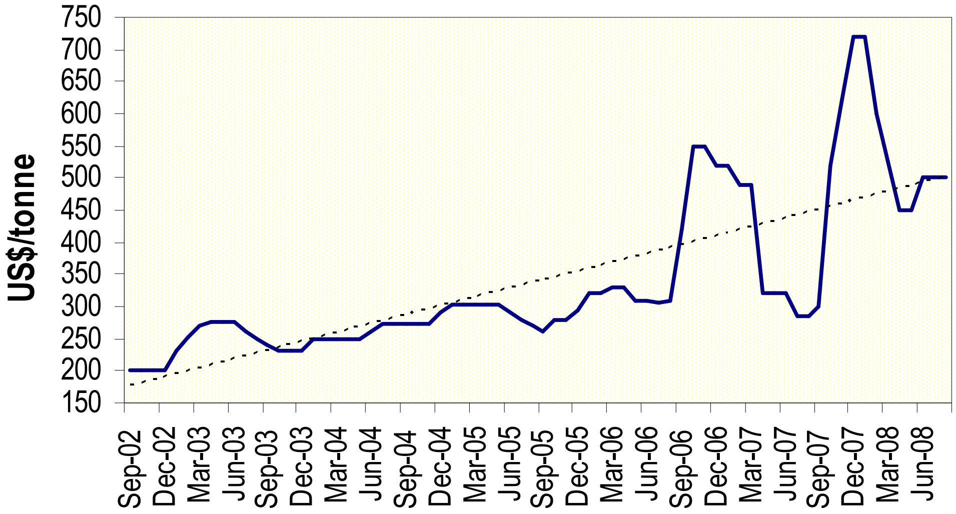
While these increases are significant, they are lower multiples than other energy forms such as oil. Prices have been supported over this period by plant throughput reduction due to gas supply issues and closure of older plants in developed countries due to the high price of natural gas.

---

[34] Dimethyl-ether is an ether produced by dehydration of methanol that can be used in diesel engines or petrol engines (blended with liquefied petroleum gas (LPG))

[35] Methanex news release – Second quarter 2008 results

**Figure 22** International Methanol Prices (Asian Posted Contract Price)




Source: www.methanex.com/products/methanolprice.html

Methanol production needs to compete with other uses of 'stranded' natural gas, such as Urea and/or Liquefied Natural Gas (LNG). LNG use and demand is growing rapidly with a large number of projects worldwide being actively marketed for development. The rise of natural gas prices in the major consuming markets (North America, Europe and Asia) are feeding back through into resource value, even when stranded, because of the ability to monetise the asset with LNG. This increase in natural gas resource value (also linked to crude oil price increases) is likely to support methanol price to some extent.

In many ways the methanol price has 'caught' and overtaken the impact of the natural gas rises in New Zealand after the end of the Maui contract volumes (2004). Likewise, rises in international gas prices now makes New Zealand's gas price at around NZ$6-7/GJ far less expensive than it seemed when Pohokura contracts were being agreed in 2004. As a consequence the decision by Methanex to reopen their larger Motunui plant is not surprising economically – it is just a matter of gas availability.

*Urea*

Urea prices have also been much stronger in recent years (even discounting the 2008 spike). Given they use the same feedstock (natural gas) the rising prices for oil and gas worldwide are obviously having an impact on the urea market as well. However it is also a demand led rise and good worldwide economic growth in recent years has led to a greater demand for agriculture produce and hence a greater demand for fertiliser. As in the past, there is still expected to be an element of boom and bust following the addition of new capacity. Figure 21 above shows the price trend for the last ten years. When the price is around US$100/tonne commentaries suggest many in the industry are losing money[36].

[36] http://www.fertilizerworks.com/html/market/NitrogenInTheNineties.PDF

If the additional capacity built exceeds market demand, the outlook may be for low urea prices as producers compete on short run economics to maintain plant loading. As well as that, the economics of some plants may be underpinned by low gas prices (e.g. developing countries seeking to monetise gas resources for economic and political reasons).

### 5.2.4. Developments in supply elsewhere

*Methanol*

As discussed in the preceding section, a number of new methanol plants have been proposed. The most recent plant addition is in Saudi Arabia (2$^{nd}$ quarter 2008) with plants under construction in Malaysia and Iran (excluding China capacity). While these new plants are large scale (1.7 million tonne per year) capacity addition is still largely being offset by closure of smaller plants that are no longer economic due to high feedstock prices.

China has become a major player in the methanol market, as with other energy resources. China is a large methanol producer and does export when international prices are high but increasing costs within China (especially for feedstocks) typically mean imports are the norm with most of their methanol production being consumed in the domestic market.

As discussed most methanol plant proposals are aimed at monetising remote gas assets and, as such, have to compete with other uses for the gas such as LNG. While this trend will continue, the general rise in all gas prices (including stranded gas) means there are still opportunities for plants where a reasonably priced gas supply can be secured. This would appear to be the case in New Zealand with the reopening of the larger Motunui methanol plant.

*Urea*

Like methanol, recent high prices are encouraging new developments to be proposed. China remains a key driver and currently has a strategy of developing enough capacity to meet the bulk of its own demand. While it may be an importer of gas it is also looking at production with energy and gas feedstock supplied from coal gasification.

Within New Zealand new plant development is very unlikely. The future of the Kapuni plant will depend on availability of suitably priced gas, which looks a lot more likely than earlier in the decade, following increased supplies and higher fertiliser prices. However it should be noted that if Kapuni did close, New Zealand's need to import another 240,000 tonnes would not have a significant impact on the world market—Australia imports significantly more for example (over 1,000,000 tonnes).

### 5.2.5. GDP as Demand Driver

New Zealand GDP is not a driver of methanol production in New Zealand. Worldwide there is a link to demand for methanol through the growth in the use of products that use methanol in their manufacture. However New Zealand production is purely related to the costs of production in New Zealand relative to Methanex's other supply points to meet their market demand.

New Zealand GDP does have a stronger link to Urea demand assuming there is a relationship between GDP and agriculture sector health. However the Urea plant in New Zealand is at capacity and therefore the swing is taken in import volumes. Therefore increasing GDP is unlikely to have any impact on throughput at the Kapuni plant in the short to medium term.

## 5.3. Supply Side Analysis

### 5.3.1. Production Costs

*Methanol*

There is no detailed information on Methanex New Zealand's production costs. From offshore literature, fixed costs[37] are assumed at US$26/tonne with variable costs, including gas cost, at US$46/tonne of methanol[38]. Given the long term nature of the Jacob's Consulting analysis we assume that these costs would have been with a long run average exchange rate of 0.55 US$/NZ$. The variable cost relates roughly to a gas price Methanex would have been paying for Maui gas at the time (c.2000) (~NZ$2.00/GJ). Therefore we can take the fixed costs as costs excluding gas cost. As the study was done within this decade we assume it reflects the largely written down capital cost of the methanol plant and primarily reflects operating costs.

The energy input into the methanol plants is gas (both for fuel and feedstock) and electricity. Gas use can be calculated from production although electricity use is not known.

*Urea*

There is no detailed information on Ballance's fixed costs for its Kapuni manufacturing site. The site employs around 100 people.

Variable costs include mainly gas and electricity. Ballance's own information indicates that the plant consumes about 7 PJ per annum, producing around 240,000 tonnes of urea. Some information indicates higher production volumes (~260,000 tonnes) – we have assumed 250,000 for 7 PJ consumed. Our breakeven gas prices are assumed to be the "into plant" prices (i.e. including transport cost).

Electricity consumption is around 30 GWh/annum.

[37] excluding capital costs

[38] Jacobs Consultancy estimates a similar production cost for New Zealand (http://www.jacobsconsultancy.com/pdfs/Methanol_and_the_MTBE_IssueA4.pdf). These are inflated to 2008 dollars for use in the model.

Operating costs (essentially fixed) including salary and wages, transport/distribution etc, materials (catalyst, chemicals, water etc), general overheads and depreciation are assessed at just under $NZ 110/tonne.

### 5.3.2. Costs of Capital and Capital Turnover

*Methanol*

In order to recommission the Motunui plant, Methanex has reportedly spent US$70/million[39]. This is a significant one off cost substantially higher than a "stay in business" capital spend that might have been expected when only the Waitara valley plant was operating. As Methanex has indicated that the Waitara valley plant will also operate if there is enough gas to operate two plants, the ongoing capital spend will be higher as there are two plants to maintain.

A stay in business capital spend is estimated based on 2% of the current capital cost of the plant (a plant the size of the Waitara plant would probably cost about US$400M[40]). Therefore for the Waitara plant the stay in business capital spend is assumed at NZ$14m/year.

*Urea*

With the plant is now over 20 years old and its future more certain for the immediate future a reasonable level of capital spend is likely to be required. We assume the plant is largely written down but assume a stay in business capital spend at $NZ 3 m per annum.

### 5.3.3. Energy Efficiency

*Methanol*

Most methanol plants worldwide are built to a similar design. Since the New Zealand plants were built in the early 1980s the major change has been larger plants to get efficiency of scale (up to 5000/tonne day per unit compared to 2,500/tonne/day for the largest New Zealand unit).

Changes to efficiency have been only marginal as much of the efficiency loss is governed by the thermodynamics of the process used. Given the capital is sunk when the initial units are built there is very little scope to change efficiency. Given the uncertainty over its future it would be extremely unlikely that Methanex would spend any capital to improve efficiency.

The energy efficiency of the methanol plant is assumed to be slightly higher than assumed in the 2006 report (58% rather than 56%) based on Methanex advice. The Motunui plant is assumed to be similar efficiency to the Waitara plant.

---

[39] http://www.petroleumnews.net/storyview.asp?storyid=469564&sectionsource=s90&highlight=methanex

[40] Methanex note that the replace cost of a Waitara valley plant is probably now double (US$400m) than the US$200m used in 2005/2006 report – telecom H&T/Methanex.

*Urea*
The Kapuni plant was built around the time of development of the Maui gas field and plant efficiency reflects age and technology employed at the time. Modern urea plants are designed for about 2500-3000 tonnes per day and ammonia plants operate at lower pressures (150 versus 300 bar) with better heat integration. Given the sunk capital cost we assume that the efficiency stays at current levels.

As for the methanol plant, some of the gas is incorporated into the product and some is a genuine energy use. An assumption of 50% is made in the base case.

#### 5.3.4. GHG Emissions

*Methanol*
Greenhouse gas emissions come from the use of natural gas as fuel in the process. As gas is either used as fuel or converted into methanol we can back calculate fuel used from that not converted. Emissions are then calculated from gas used for fuel. As there is no change in efficiency, this will be constant for a constant level of methanol production. Currently, methanol production efficiency is approximately 58%. This means 0.42GJ of gas is consumed per GJ of methanol produced. Overall GHG emissions will increase with the higher throughput of the larger plant.

There are also indirect emissions from electricity use which are not modelled.

*Urea*
Direct greenhouse gas emissions come from the use of natural gas as fuel in the process. As gas is either used as fuel or converted into urea we can back calculate fuel used from that not converted. Emissions are then calculated from gas used for fuel.

We assume there is no change in efficiency and therefore gas use will be constant for a constant level of urea production.

$CO_2$ sequestered in the urea, and later emitted in on-farm use, is estimated at equal to the output of the plant in tonnes x 0.2 x 44/12.[41] The $CO_2$ emissions from gas consumed in production will depend on the gas source.

There are also indirect emissions from electricity use which are attributable to the electricity industry.

### 5.4. Cut-Off Prices

*Methanol*
Before we can estimate cut off prices we have to estimate the value of the production. For methanol virtually all production is exported. Therefore the netback to the New Zealand producer is the market price less freight. Methanex also notes that it has long-term contracts and, on average, sells at a discount to spot prices[42]. This approach has

[41] MED (2004) New Zealand Energy Greenhouse Gas Emissions 1990-2003.

[42] Methanex 2004 Annual Report pg 40.

continued in recent years although based on the data available in Methanex's recent result statements we have adjusted the percentage discount off spot price (compared to the 2006 report) as follows: 15% when the market price is at US$400/tonne (was US$300/tonne) reducing proportionally to 6% when the price is US$200/tonne (was US$150/tonne).

Methanol is shipped out of New Plymouth on chemical tankers to markets in North Asia. New Plymouth port limits now allows larger cargo sizes (up to 40,000 tonnes) since dredging in 2007. Freight rates have been highly variable in the past few years and generally much more expensive than earlier in the decade. For the purposes of this update we assume rates of US$45/tonne (versus US$27/tonne in the earlier report)[43].

Table 26 sets out the expected maximum gas price payable at different exchange rates and product values. This assumes no contribution to capital given the written off value of the New Zealand plants.

**Table 26** Maximum Gas Price payable ($/GJ) with no capital contribution

| | Exchange Rate US$:NZ$1 | | | | | | |
|---|---|---|---|---|---|---|---|
| Methanol Price (US$/t) | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 | 0.80 |
| 150 | 3.44 | 2.99 | 2.62 | 2.3 | 2.03 | 1.79 | 1.58 |
| 200 | 5.63 | 4.98 | 4.44 | 3.98 | 3.59 | 3.25 | 2.95 |
| 250 | 7.71 | 6.87 | 6.17 | 5.58 | 5.08 | 4.64 | 4.25 |
| 300 | 9.68 | 8.67 | 7.82 | 7.10 | 6.49 | 5.95 | 5.49 |
| 350 | 11.55 | 10.36 | 9.37 | 8.54 | 7.82 | 7.20 | 6.55 |
| 400 | 13.31 | 11.96 | 10.84 | 9.89 | 9.07 | 8.37 | 7.75 |
| 450 | 14.96 | 13.46 | 12.21 | 11.16 | 10.25 | 9.47 | 8.78 |
| 500 | >15.0 | 14.86 | 13.50 | 12.34 | 11.35 | 10.50 | 9.75 |

Although a high NZ/US exchange rate as seen in recent years will temper the returns available, the table shows that at current methanol prices of US$500/tonne methanol production should be quite profitable.  However Methanex would need to recover well over NZ$100/tonne above the break-even for a full year's production to offset the Motunui recommissioning cost. As long as methanol prices stay above US$300/tonne and there is reasonable priced gas available, it is likely that Methanex could continue to operate some of their New Zealand plant.

The figures in Table 26 do not include a carbon charge.  A carbon charge at NZ$ 25/tonne $CO_2$ on total gas intake would decrease the figures in Table 26 by NZ$ 1.30/GJ. However exports of methanol would be rebated applicable carbon charges on the carbon sequestered in the methanol, reducing the actual charge to Methanex[44]. Based on

[43] Calculated using a 'Worldscale' rate to North Asia multiplied by a typical rate for a 30,000 tonne chemical tanker. This is a similar figure to that estimated by Jacobs Consultancy.

[44] More than half of the carbon in the natural gas remains in the methanol and does not result in any carbon dioxide emissions in production. The ETS would allow a rebate for this carbon if the natural gas had incurred an emission charge (with the assumption that all the natural gas was going to be burnt in New Zealand and thus emit $CO_2$).

a $NZ25/tonne $CO_2$ cost, the net emissions charge would cost Methanex approximately NZ$22/tonne of production (approximately NZ$20 million per year with the higher throughput Motunui plant).

The above economics demonstrate the rational behind Methanex's recent decision to invest to restart moth-balled production capacity in New Zealand. It also explains why they would be prepared to run both plants (Motunui and Waitara) if sufficient gas resources can be secured.

*Urea*
Before we can estimate cut off prices we have to estimate the value of the production. For urea, Kapuni does not produce enough to satisfy total New Zealand demand. The balance has to be imported. Therefore the value for Kapuni production is derived from the alternative cost of imports (commodity urea price plus freight less distribution costs to shift production from Taranaki to other points in New Zealand[45]).

Urea is shipped to New Zealand in Handymax/Handysize shipping parcels, with maximum parcel size around 25-30,000 tonnes. Time charter rates for these sorts of vessels were reasonably low early in the decade but have since generally been much higher. For the purposes of this analysis we assume a freight rate for imports at $US 39/tonne (versus US$26/tonne in the earlier report)[46].

We discount the import parity value plus international freight by a percentage (10%) reflecting that domestic manufacturing needs to ensure competitiveness versus imports. The freight cost is based on an assumed 30,000 tonnes Dwt Handysize vessel, based on a voyage from Canada (British Columbia to New Zealand).

Table 27 sets out the expected maximum gas price payable at different exchange rates and product values. This assumes no contribution to capital given the written off value of the New Zealand plant.

**Table 27** Maximum Gas Price payable ($/GJ) with no capital contribution

| | Exchange Rate US$:NZ$1 | | | | | | |
|---|---|---|---|---|---|---|---|
| Urea Price (US$/t) | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 | 0.80 |
| 150 | 7.81 | 6.71 | 5.8 | 5.02 | 4.35 | 3.77 | 3.26 |
| 200 | 11.01 | 9.63 | 8.48 | 7.49 | 6.64 | 5.91 | 5.27 |
| 250 | 14.24 | 12.55 | 11.16 | 9.96 | 8.94 | 8.05 | 7.28 |
| 300 | >15.0 | >15.0 | 13.83 | 12.44 | 11.23 | 10.2 | 9.29 |
| 350 | >15.0 | >15.0 | >15.0 | 14.91 | 13.53 | 12.34 | 11.3 |
| 400 | >15.0 | >15.0 | >15.0 | >15.0 | >15.0 | 14.48 | 13.31 |
| 450 | >15.0 | >15.0 | >15.0 | >15.0 | >15.0 | >15.0 | >15.0 |
| 500 | >15.0 | >15.0 | >15.0 | >15.0 | >15.0 | >15.0 | >15.0 |

[45] For the purpose of our analysis we assume Kapuni supplies North Island demand i.e. nothing is shipped to the South Island.

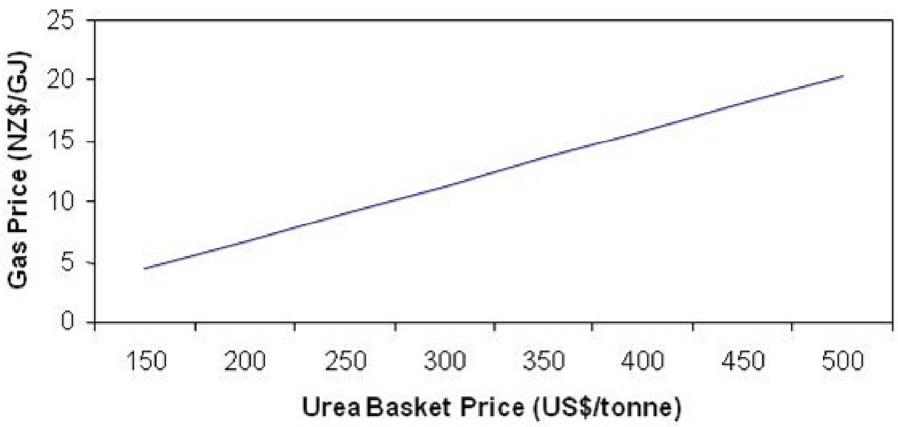
[46] http://www.galbraiths.co.uk/pdf/Handy_TC_Rates.pdf

The table highlights that at an exchange rate of 0.7, the price of gas in New Zealand makes urea production marginal at international urea price levels below $US 200/tonne. Figure 23 shows the gas price which makes the urea production in New Zealand breakeven at a 0.70 exchange rate.

The figures in Table 27 do not include a carbon charge. A carbon charge at NZ$ 25/tonne $CO_2$ on total gas intake would decrease the figures in Table 27 by NZ $1.30/GJ. This assumes that all gas used is deemed to incur a carbon charge. Assuming only process and energy emissions are charged (not $CO_2$ left embedded in the fertiliser) the actual charge would be $NZ0.65/GJ on gas input or $NZ 18/tonne of urea produced.

The above figures make no allowance for the effect of a carbon charge on electricity price which is not modelled.

**Figure 23** Urea Breakeven Gas Price ($/GJ)




Based on movements in the fertiliser price over the past few years it can be concluded that the longer term viability of urea manufacture in New Zealand is sound as long as sufficient gas supplies can be obtained. It seems likely that fertiliser prices, while they may decline from current high levels will stay above the breakeven point needed to ensure continued manufacture in New Zealand.

Current prices would justify continued production even if the gas supply (and price) was LNG imports. However it may be unlikely that Ballance would be prepared to commit to long term LNG gas supply (at a high price) since the urea price may be subject to a different commodity cycle.

## 5.5. Projections of Energy Use

In the 2006 report methanol was not expected to be produced in New Zealand beyond 2007. Methanex has now said they have gas supplies through to the mid 2010 and indications are they are looking at producing well beyond that date. They are optimistic about the outlook for gas and, even with no new discoveries think production towards the middle of the next decade is possible (2013+). The actual production level over this period will be dependent on gas availability. For forecasting, MED should look at their gas production forecasts to see what level of production matches likely gas availability.

For the purposes of this report we assume production level at the throughput of the higher Motunui plant (~33PJ) until the end of 2011 (just over 3 years) before reducing to the average throughput of the smaller Waitara plant (~19PJ) through to 2015.

Beyond this we expect the methanol plants will still be economic to run but it may depend on further gas discoveries or expansion of current reserves to provide the necessary gas feedstock.

The Balance fertiliser production is expected to continue to operate and secure the necessary gas supply. Energy demand is forecast to be a constant 7PJ per annum.

## 5.6. Energy Projections

**Table 28** Annual Energy Demand Projection (PJ)

| | Methanol | | | | Urea | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Production (kt) | gas intake (PJ) | Consump-tion (PJ) | Embodied (PJ) | Production (kt) | gas intake (PJ) | Consump-tion (PJ) | Embodied (PJ) | Electricity GWh | Total $CO_2$ methanol + urea (kt) |
| 2007 | 428 | 17.1 | 9.9 | 7.2 | 238 | 6.7 | 3.3 | 3.4 | 28.6 | 545 |
| 2008 | 565 | 22.5 | 13.1 | 9.5 | 250 | 7.0 | 3.5 | 3.5 | 30 | 672 |
| 2009 | 853 | 34.0 | 19.7 | 14.3 | 250 | 7.0 | 3.5 | 3.5 | 30 | 923 |
| 2010 | 853 | 34.0 | 19.7 | 14.3 | 250 | 7.0 | 3.5 | 3.5 | 30 | 923 |
| 2011 | 853 | 34.0 | 19.7 | 14.3 | 250 | 7.0 | 3.5 | 3.5 | 30 | 923 |
| 2012-15 | 477 | 19.0 | 11.0 | 8.0 | 250 | 7.0 | 3.5 | 3.5 | 30 | 596 |
| 2016-35 | 0 | 0 | 0 | 0 | 250 | 7.0 | 3.5 | 3.5 | 30 | 181 |

# 6. Oil Refining

## 6.1. Description

New Zealand has one oil refinery located at Marsden Point near Whangarei. The refinery processes crude oils (largely imported) and residues into a range of products for the New Zealand market. These products include petrol, jet fuel, kerosene, diesel, fuel oil and bitumen. Sulphur for the fertiliser industry and $CO_2$ for the beverage industry are produced as by-products of the main process.

The refinery is owned and operated by the New Zealand Refining Company Limited (NZRC). The refinery was initially set up with Government support in 1964. It underwent a major expansion in the mid-1980s, increasing throughput and adding new upgrading capacity. Following deregulation of the oil industry in the late 1980s, much of its debt was taken on by the Government with NZRC left to run as a fully commercial operation.

About 73% of NZRC is owned by the four major oil companies operating in New Zealand (BP, Chevron(Caltex), Mobil and Shell) that are also NZRC's main customers. Institutional and general public investors hold the remaining 27%, with the shares listed on the New Zealand Stock Exchange. The Government has had no direct involvement in the refinery following the debt write-off in the late 1980s.

The business model for NZRC is unusual. Typically refineries are integrated into an oil company's upstream (oil production) and downstream (product wholesaling and retailing) interests, being part of the supply chain delivering petroleum products to customers. NZRC is different in that it is only a refiner[47]—its income is generated largely from processing crude oil into products. NZRC's customers contract capacity at the refinery to process their own crude oil into the products they desire. NZRC competes on providing a competitive refining service for its customers.

Refineries are large capital-intensive businesses. They are significant energy consumers, although most of the energy is provided by consumption of some of the energy in the crude oil and feedstock that is being processed into product. Approximately 7% (by mass) of the feedstock is consumed as energy during the refining process. Electricity is the major other energy used. As a result of this energy consumption greenhouse gas emissions are high—over 1 million tonnes of $CO_2$ per year. In 2003 NZRC secured a Negotiated Greenhouse Agreement (NGA) whereby the New Zealand Government agreed to exempt NZRC from the impact of a carbon charge in return for moving to world's best practice in managing greenhouse gas emissions. NZRC report that the NGA is still valid and applying to its operation despite the changes in Government policy since that time.

[47] NZRC also owns a pipeline for delivery of product to Auckland. This is not a significant energy user so is excluded from the analysis.

## 6.2. Domestic and International Markets

### 6.2.1. The Markets

While NZRC is the only refinery in New Zealand it competes in an international market. Both its feedstock and products are commodities that can be purchased from numerous sources. NZRC needs to ensure that the cost of processing through its refinery is competitive with buying and importing product directly.

At full capacity NZRC produces less than the New Zealand market demand for product. NZRC has run at full capacity for most of the last decade and, averaging the last three years production and demand (April 2005 - March 2008), NZRC provided the following proportion of the market[48]:

| | |
|---|---|
| Petrol | 64% |
| Jet Fuel | 79% |
| Diesel | 70% |
| Fuel Oil | 100%[49] |

With NZRC not capable of producing the full market demand for white products[50], the balance of the market demand is supplied by imports. Imports can be sourced from a number of refineries in different countries in the region. Generally they are sourced from the Asia-Pacific region as freight costs limit imports from further afield.

New Zealand's main supplying countries for imports are Singapore, Australia, South Korea and Taiwan.[51] Singapore is the major export refining centre in the region and is the basis for regional oil product commodity markets. Product supplied from other countries in the region is always related to the Singapore price. More recently there has been a shift in source away from Australia (from 2008) to greater volumes from Asia.

With imports supplying the balance of the market, NZRC uses the import price (known as import parity) to establish the value of its products. It generates its revenue from the margin between the value of those products and the cost of the feedstock processed (imported crude oil). This is known as the Gross Refining Margin (GRM).

While the refinery is significant in the New Zealand market, it is a small refinery by international standards. NZRC capacity is approximately 110,000 bbl/day, which is about a quarter to one third the size of some of the major Asian export refineries. However NZRC has an advantage due to its location. Crude oil is imported on large ships in up to 120,000 tonne shipments. While these often come from a greater distance than product imports (the Middle East is a major supplier), product imports are typically supplied on ships of 35,000 tonnes. The greater scale of crude shipments means that it is more cost effective to ship crude than product, giving NZRC a competitive

[48] Source Energy Data File July 2008

[49] Fuel Oil is exported from the refinery as production is generally excess to New Zealand's demand

[50] White products are petrol, jet and diesel

[51] Source: Statistics New Zealand

advantage for supplying New Zealand of between US$0.50- US$1.00/bbl versus a refinery in another location. However this competitive advantage tends to work in reverse if NZRC exports, which is why it is commercially prudent for NZRC to avoid investment in capacity surplus to the New Zealand market requirement.

The market for refined petroleum products (petrol, jet and diesel) in New Zealand grew rapidly until the middle of this decade (41%)[52] driven especially by increasing jet fuel and diesel demand. While the refinery intake increased by about 17% over the same time period, most of the petroleum market growth has been met by the decline in exports as capacity surplus came into balance with market demand, and then the growth of imports. The substantial increase in crude and product prices in the last five years (especially 2008) appears to have eroded product demand growth. While any demand drop within New Zealand is unlikely to affect NZRC's throughput any global demand drop can result in lower refining margins.

NZRC is now expanding capacity to meet some of demand currently met by imports (covered in section 6.2.5).

### 6.2.2. Drivers of Market Demand

The market for NZRC product is almost entirely driven by the demand for transport fuels. Transport is one of the key drivers/dependencies of a modern economy and typically grows in a similar trend to GDP.[53] Many alternatives to petroleum fuels for transport are being proposed such as biofuels (ethanol, biodiesel) and hydrogen. However petroleum fuels remain the most cost effective high volume transport fuel and are expected to retain their dominance for the next few decades[54] as most alternatives will only be suitable for niche or limited use.

The New Zealand Government has introduced regulation for the introduction of biofuels putting an obligation for petroleum fuels marketers to sell at least 2.5% biofuel (on an energy basis) by 2012. The current expectation is this will largely be met by using ethanol which will reduce demand for petrol. The alternative is to use biodiesel to back out diesel demand (currently less economic). In both cases the volumes are small so it is unlikely to impact on NZRC's production level (it will substitute a small volume of product imports).

While transport using electric vehicles is also being promoted, it is likely to be some years (at least 10) before this would have an impact on petroleum fuels demand.

---

[52] Energy Datafile January 2005

[53] The World Business Council for Sustainable Development study Mobility 2030 has a section on whether GDP growth drives transport growth or the other way round. The conclusion is that they are interdependent rather than a dependency one on another.

[54] WBCSD Mobility 2030

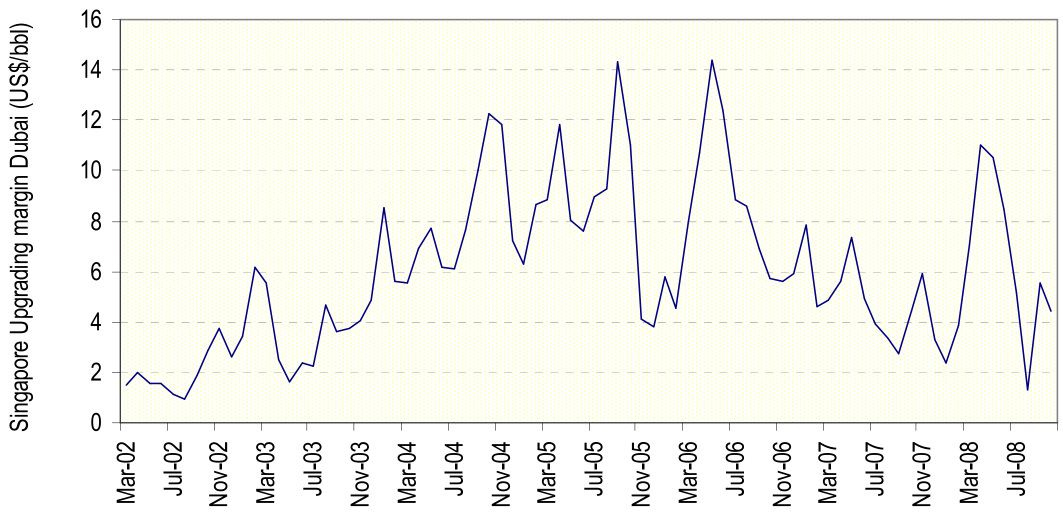
### 6.2.3. Trends in Commodity Prices

Although NZRC's inputs (crude oil) and outputs (refined product) are traded commodities, its profitability is not driven by absolute prices. Rather profitability is driven by the margin between crude and product. NZRC charges its customers a margin based on the value of the output less the cost of the input. This is expressed as follows:

Margin = $\sum$ (volume of product produced * value of product) – cost of crude import

While each refinery has a unique margin because of individual configuration and capacity type, there are indicator margins developed for a typical Singapore refinery. A margin for upgrading of heavy crude is shown in Figure 24.

**Figure 24** Singapore Upgrading Margin



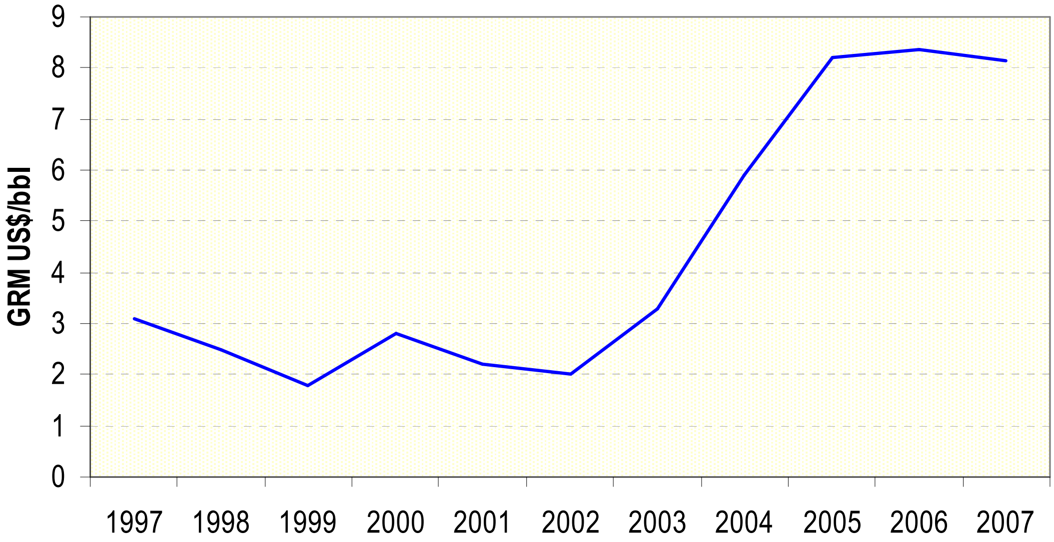

Source: Argus Petroleum Weekly

NZRC's margin trend is slightly different than the generic margin staying at higher levels (around US$8/bbl) in recent years. NZRC processes a mix of heavy and light crude (light crude margins are lower than those for heavy crude).

The driver for increased refinery margins has been the global demand for refined products driven by worldwide growth especially in China and India. This growth has put the refining sector under pressure as there hasn't been a corresponding capacity expansion. New refining capacity can take time to construct so margins have been strong for some time. It should be noted that before this period of high margins, refinery margins had been low for most of the last 10 years. While NZRC remained profitable during this period[55] it is arguable as to whether they were generating enough income to justify any new investment or expansion.

[55] With one exception in 1999 when the refining side of the business had a loss. That was more than offset by the profit from the pipeline business.

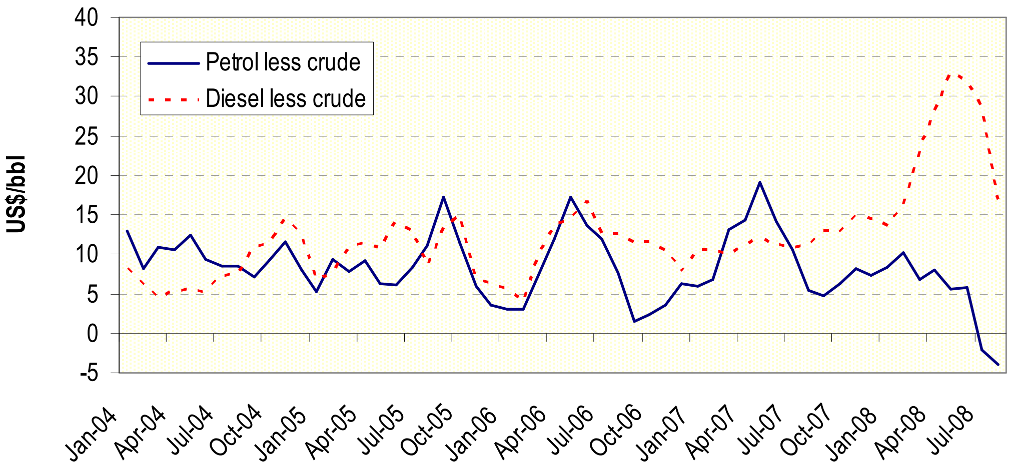
**Figure 25** NZRC Gross Refining Margin




Source: NZRC Annual Reports

NZRC's margin has been particularly strong over the past few years (2005-2008) because it produces a relatively high proportion of jet fuel and diesel. The refining margin for these products has been particularly strong. Figure 26 plots petrol and diesel benchmarks versus a crude mix (Tapis and Dubai). Whereas historically petrol has been more expensive than diesel, in recent years diesel has mostly had a higher value than petrol.

**Figure 26** Benchmark petrol and diesel prices versus crude




Source: Platts/Hale & Twomey

While refining margins have been very high compared to historical averages in recent years, they are not expected to remain at this level. In the second half of 2008 there are large refineries being brought on line in Asia which may reduce margins for a time, as will a lower demand for products following 2008s high prices.

### 6.2.4. Developments in supply elsewhere

Historically refining has shown a tendency to boom and bust cycles, with higher margins (like those recently) encouraging major expansions and new developments which then outstrip demand, leading to weaker margins which fail to give an adequate return on the new investment. While the industry has been more cautious about future investment in this cycle, there are large new refineries being streamed in Asia, which coupled with reduced demand growth, is expected to lead to a period of lower margins.

The major change for New Zealand supply in this decade is that Australia has moved from being long on refinery capacity to short. In 2003 the smallest of Australia's eight major refineries was shutdown. Although it was not said to be a permanent shutdown, the refinery's owner, ExxonMobil, has shown no sign of reconsidering the decision despite buoyant refining margins since the announcement. The change in Australia's refining balance is leading to a reduction of product imports from Australia (which used to be New Zealand's largest supplier) to be replaced by imports from Singapore and North Asia.

### 6.2.5. GDP as Demand Driver/refinery expansion

As discussed in Section 6.2.2, the demand for petroleum products is strongly linked to GDP. However NZRC is at capacity so that market growth is having no impact on its energy use or emissions. The growth is being met by imports. Conversely if high prices reduce demand, it is only likely to reduce demand to a level where imports are affected rather than NZRC demand.

Over the past decade NZRC has fallen from producing over 80% of New Zealand's fuel to producing about 70%. NZRC has seen an opportunity to expand their capacity while remaining short of the total market (the project is known as the Point Forward Project). While crude capacity is expected to increase by around 20%, the net output gain will only be 10-12% as other feedstock (residue) will be backed out (substituted)[56]. The expansion is due to be commissioned late in 2009 so has been included in the model from 2010.

## 6.3. Supply Side Analysis

### 6.3.1. Production Costs

The key production costs for NZRC are operating costs. While a significant amount of energy is used in the process, much of this comes from the feedstock. While feedstock costs vary substantially, the impact of the use of this fuel is built into the margin (if it is used in the process it is not producing product that can be priced) rather than paid for directly. It is also owned by the company processing rather than NZRC. NZRC can obtain a benefit from being more efficient, as using less fuel will increase product make therefore improving the margin and hence income.

[56] http://www.crownminerals.govt.nz/cms/news/2008/marsden-point-oil-refinery-expansion-project-underway/

NZRC can use natural gas directly for fuel and process unit intake (to produce hydrogen). As it is used in the process interchangeably with fuel from feedstock, depending on economics, natural gas use is also priced into the margin and hence effectively paid for by the processors.

The only energy paid for directly by NZRC is electricity. Continuous demand is about 29MW.[57] Electricity costs have varied between $11 million and $25million in this decade although electricity costs are no longer stated separately in the annual report so the annual amount is not available from 2004; the high figure was in 2003 when NZRC was unhedged and so suffered during the electricity crisis of that year – recent years may be closer to this level with further shortages in the electricity sector. Table 29 shows recent trends in operational costs.

**Table 29** NZRC Operational Data

| | 2007 | 2006 | 2005 | 2004 | 2003 |
|---|---|---|---|---|---|
| Crude & residue feedstock (kt) | 4.64 | 4.86 | 4.81 | 4.72 | 4.92 |
| Operating Costs[58] ($million) | 128.2 | 145.2 | 130.1 | 91.1 | 75.3 |
| Electricity ($million) | - | - | - | 15.0 | 25.0 |
| Depreciation ($million) | 58.7 | 54.9 | 24.3 | 24.1 | 24.2 |
| Other ($million) | | | -2.5 | - | 5.5 |
| Electricity usage (PJ) | 0.91 | 0.94 | 0.91 | 0.835 | 0.86 |
| Electricity/tonne feedstock (GJ/tonne) | 0.196 | 0.193 | 0.189 | 0.176 | 0.175 |
| Fuel use (PJ)[1] | 15.50 | 15.97 | 15.15 | 14.52 | 15.01 |
| Fuel use/tonne feedstock | 3.33 | 3.29 | 3.14 | 3.08 | 3.05 |
| Carbon Dioxide Emissions | 1.128 | 1.160 | 1.080 | 1.017 | 1.054 |

[1] Includes refinery fuel gas and fuel oil

Source: NZRC Annual reports

Most of these costs are New Zealand-based expenses (except for some materials and catalysts). However the margin income is entirely US$ based. Therefore NZRC has a significant exposure to the exchange rate as well as the underlying margin.

In general most of the costs are fixed with little flexibility. During the low margin period from 1998 through 2002 NZRC expenses averaged $110 million, which was a time of tight control of costs because of low profitability.

NZRC's operating costs have increased over the past few years to average between NZ$125-130 million (note there was a $21 million operating expense charge for the Point Forward project in the 2006 accounts).This is quite a lot higher than the previous level and seems to be largely caused by increases in the purchase of process materials, utilities and materials.

The commissioning of new units to produce the higher quality products in the second half of 2005 will have increased both operating costs and fuel use. In addition costs for

[57] All data from NZRC Annual Reports

[58] Since the 2004 Annual Report NZRC has not broken out electricity costs

refining are rising faster than average inflation – the Oil and Gas Journal reports refinery operating cost indexes rising between 5 and 10% per year in recent years[59].

As an import substitution business if NZRC's costs rise, such as for the 2003 electricity spike, NZRC has no ability to pass this on to its customers. Cost increases come directly off profit. However it should be noted that there is a market premium for the higher quality products, so while the new processing units have increased costs they have also improved the margin through being able to charge a premium for the products. Some of NZRC's margin increase in recent years relates to the higher quality products being produced rather than general margin increase.

### 6.3.2. Costs of Capital and Capital Turnover

Refineries are long life assets (40 years+) that will go through periods of expansion and upgrading. Even when units are reaching 40 year lives (such as the case for NZRC's initial units) the asset is usually maintained by upgrading and replacing parts of the units that allow lives to extend. The most sophisticated upgrading units at NZRC were built in the 1980s so are not very old by refining standards.

NZRC capital spending has also increased in recent years both in base capital spend and for projects. With more processing units NZRC now has to spend more on catalysts. They have also reported large spends on shutdown and tank maintenance (not just in shutdown years). Like operating costs, reported indexes for refinery construction costs are also increasing faster than general inflation. Table 30 estimates capital split between new projects and base capital spend.

**Table 30** NZRC Capital Spend (NZ$ million)

| | 2007 | 2006 | 2005 | 2004 | 2003 |
|---|---|---|---|---|---|
| Base Capital Spend | 38 | 17 | 24 | 16 | 13.1 |
| Catalyst | 26 | 1 | 6 | 9.5 | 0.2 |
| Future Fuels | | | 50 | 114 | 16 |
| RAP[60] expansion | 1 | | 8 | 2 | |
| Point Forward expansion | 29 | 14 | | | |

Source: NZRC Annual report with project split estimated

The major $180 million investment for new processing units to meet tighter fuels quality specifications was completed in 2005. There was also significant spend on increasing the refinery to Auckland (RAP) pipeline. Since 2005 NZRC had been investigating expansion opportunities (Point Forward) and the decision to move ahead with this expansion was made in April 2007. The project involves the expansion of the original (1960s) crude distillation unit from 60,000 barrels per day to 95,000 barrels per day and is estimated to cost NZ$180 million.[61]

[59] Oil & Gas Journal, July 7 2008: Nelson-Farrar Cost Indexes

[60] Refinery to Auckland Pipeline

[61] NZRC 2007 Annual Report

NZRC's WACC (as published by Price Waterhouse Coopers[62]) has increased to 10.2% (nominal after tax) from 8.4% in the earlier report, in line with increases in the general market WACC. Arguably the refining section of the business has more risk than the pipeline business so the WACC would be a little higher if the pipeline business is removed.

### 6.3.3. Energy Efficiency

Although the Government has moved away from using negotiated Greenhouse Gas Agreements (NGA) in their greenhouse gases policy, the Government and NZRC expect to continue operating under the NGA program.[63] To meet their obligations NZRC is committed to achieving world best practice in energy efficiency. This involves capital expenditure, maintenance programs and operating procedures. NZRC report that to date they have met or exceeded the requirements of the Agreement.

The energy efficiency targets are confidential. NZRC has a strong financial incentive to be as energy efficient as possible so we assume that most efficiency improvements are related to some capital spend for new more energy efficient equipment. Such a spend may be included in the capital spend in the last few years. For the purposes of the updated modelling we have assumed the following:

| | |
|---|---|
| Improvement of electricity use/annum: | 0.25% |
| Improvement in fuel use/annum: | 0.25% |
| Additional Capital spend to get efficiency benefit | NZ$1.5 million/year[64] |

These assumptions are lower than those assumed in the 2005/2006 report. With the new units streamed in 2005 and a large maintenance turnaround in 2007 it is impossible to see from the published data if there is an ongoing energy efficiency as is being assumed.

### 6.3.4. GHG Emissions

NZRC's GHG emissions primarily come from fuel used in the refining process. Both emissions and the emission/tonne feed data are provided in the annual report. We have built this data into the assessment along with the efficiency assumptions above.

Recent annual reports have data reflecting higher emissions since new units were commissioned to meet higher product quality slightly. The higher quality fuels require more severe processing which necessitates greater energy use. Actual data since 2006 (post new units) has been used to update the model.

The expansion in refinery throughput will increase energy use and emissions but not quite as much as expected from the throughput increase due to efficiency improvements. While the total throughput is increasing 10-12%, the increase in fuel use

[62] March 2008 report: www.pwc.com/nz/eng/ publications/Cost_of_Capital_Mar_08.pdf

[63] NZRC 2007 Annual Report

[64] Calculated based on a economic return given the efficiency improvements

and electricity use is assumed to only be 80% of this level (i.e. an 8-10% increase). [65] The project should increase profitability through the increased volumes rather than any change in underlying margin.

With an emissions charge being introduced, in theory NZRC could have an additional operating cost of NZ$29 million/annum at NZ$25/tonne $CO_2$ with current throughputs. However as noted, NZRC and the Government expect to continue to operate under their NGA agreement which will protect them from this charge.

## 6.4. Cut-Off Prices

The margin split between NZRC and its customers (70%/30% respectively) is designed so that NZRC remains competitive against imports across a range of investment scenarios. In recent years there have been low average margins (~US$2/bbl) and high margins (~US$8/bbl) and, through it all, NZRC has operated at capacity. Therefore we can conclude that across the range of margins that are likely to make NZRC economic, their customers will continue to fully utilise NZRC (they are competitive versus the import equivalent).

The cut-off price analysis is therefore primarily around the margin NZRC needs to remain profitable and in the case of changes in electricity price, how those prices impact on the margin NZRC requires to remain profitable. NZRC margin is driven by both the level set by international markets in US dollars and NZ/US dollar exchange rate. Typically breakeven margins for NZRC (~US$3.00-4.00/bbl) mean that margins for many other refineries in the region are negative (because of quality and location advantages). Therefore even in a low margin environment NZRC is likely to 'sit it out' and wait for other refineries to close (as has happened earlier this decade). The primary immediate impact of a low margin environment will be to defer any possibility of expansion.

**Table 31** Maximum Electricity Price payable ($/MWh) with cash costs

| | Exchange Rate US$:NZ$1 | | | | | | |
|---|---|---|---|---|---|---|---|
| Margin[66] (US$/bbl) | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 |
| 2.50 | <0 | <0 | <0 | <0 | <0 | <0 | <0 |
| 3.00 | 50 | <0 | <0 | <0 | <0 | <0 | <0 |
| 3.50 | 152 | 81 | 23 | <0 | <0 | <0 | <0 |
| 4.00 | >200 | 174 | 108 | 51 | 3 | <0 | <0 |
| 5.00 | >200 | >200 | >200 | >200 | 149 | 97 | 52 |
| 6.00 | >200 | >200 | >200 | >200 | >200 | >200 | 179 |
| 7.00+ | >200 | >200 | >200 | >200 | >200 | >200 | >200 |

Table 31 highlights that electricity pricing, while a key cost for NZRC, is only likely to impact NZRC operation in a low to moderate margin environment. An electricity movement from NZ$70/MWh to $90/MWh impacts NZRC profitability by a little over

[65] Based on advice in telecon Hale & Twomey/NZRC

[66] This is a margin based on the current NZRC GRM which is post any improvement following the commissioning of the future fuels project (improvement from higher quality products)

NZ$5.0M before tax (about $5.5m post expansion). In the context where refinery margin has varied by US$5/bbl over the past five years and refinery pretax profit has varied by nearly NZ$200 million, electricity is very much a second order factor for refinery business decisions.

However with the increase complexity of the refinery (new units to make higher quality products), electricity use has increased as have overall costs. Therefore the refinery generally needs a higher margin now to break even (compared to the 2006 report). Therefore the point at which electricity costs might impact on production decisions is at a higher margin than calculated in the 2006 report[67].

## 6.5. Energy Demand Projections

Projected energy demand at NZRC is shown in Table 32.

**Table 32** Projected Energy Demand and Emissions

| | Prod-uction | Prod-uction | Fuel use | Oil consumption | Oil consumption | Electri-city efficiency | Electricity use | Electricity | CO2 |
|---|---|---|---|---|---|---|---|---|---|
| | Mt | Mbbls | % | kt | PJ | kWh/t | GWh | PJ | Mt |
| 2008 | 4.7 | 37.9 | 7.3% | 350.7 | 15.8 | 53.6 | 256.8 | 0.92 | 1.14 |
| 2009 | 4.7 | 37.9 | 7.3% | 349.9 | 15.7 | 53.5 | 256.2 | 0.92 | 1.14 |
| 2010 | 5.3 | 42.1 | 7.1% | 379.0 | 17.1 | 52.2 | 277.5 | 1.00 | 1.23 |
| 2015 | 5.3 | 42.1 | 7.0% | 374.3 | 16.8 | 51.5 | 273.9 | 0.99 | 1.22 |
| 2020 | 5.3 | 42.1 | 7.0% | 369.7 | 16.6 | 50.9 | 270.4 | 0.97 | 1.20 |
| 2025 | 5.3 | 42.1 | 6.9% | 365.1 | 16.4 | 50.2 | 266.8 | 0.96 | 1.19 |
| 2030 | 5.3 | 42.1 | 6.8% | 360.5 | 16.2 | 49.5 | 263.3 | 0.95 | 1.17 |
| 2035 | 5.3 | 42.1 | 6.7% | 356.0 | 16.0 | 48.8 | 259.7 | 0.93 | 1.16 |

[67] Also noting that NZRC margins have improved relative to international benchmarks due to the premium for the higher quality products produced

# 7. Dairy Processing

## 7.1. Description

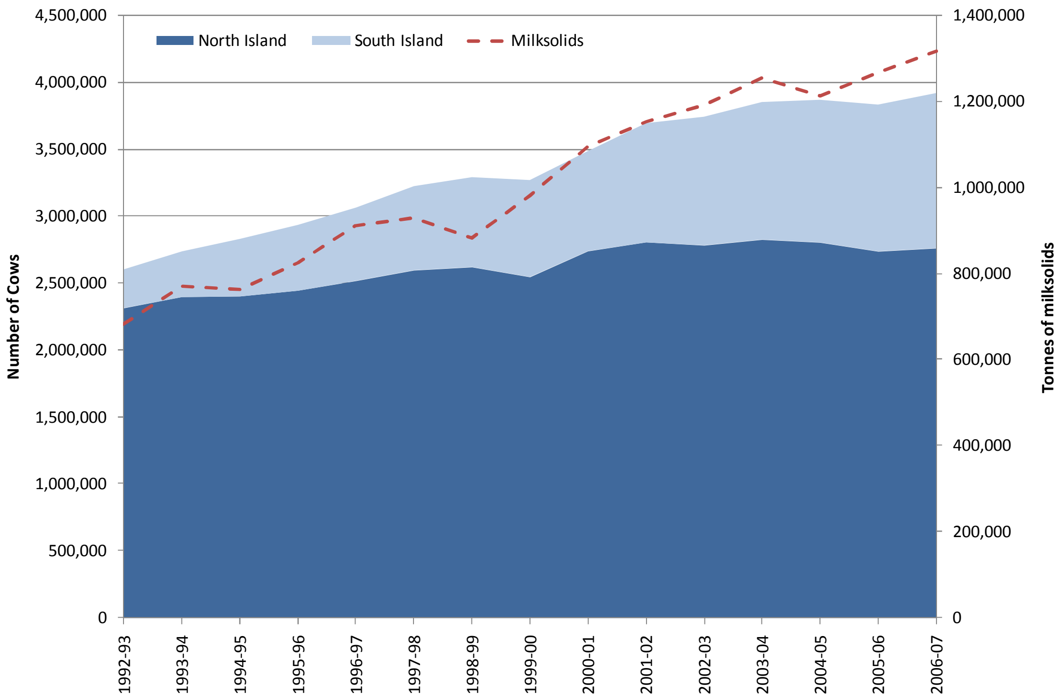
The dairy industry in New Zealand is largely co-operatively owned and operated. It is dominated by a single company, Fonterra, which claims 11,000 shareholding suppliers and 95% of all dairy farmers in New Zealand. Fonterra is a fully integrated firm in the sense that, in concert with its shareholding farmers, it has control over the entire supply chain from raw milk production through processing to the marketing of a range of branded and commodity products.

There are two other significant integrated co-operative companies operating. Westland processes milk from 380 suppliers in its Hokitika facility, and Tatua has 124 farmer shareholders and is based near Morrinsville, Waikato. There are also a large number of smaller firms that manufacture final products using milk drawn on the basis of direct supply agreements with farmers.

### 7.1.1. The Chain of Production

Production levels are ultimately dictated by the volume of milk flow from farms. Output has been expanding consistently over the last twenty years as a combination of efficiency improvements and appreciation in the market valuation of end-products has increased export earnings per cow. Figure 27 shows the trends in cow numbers and in milksolids production. The most significant growth is in the South Island.

**Figure 27** Cow Numbers and Milksolids production




Source: DairyNZ

Milk is processed into a large range of products, the vast majority of which are exported (95% of Fonterra's production). Dried products include whole and skim milk powder, for which there is substantial international demand, and casein. Butter and cheese are the other large volume products, however there are numerous specification differences within each of these categories. Newer products include a range of ingredients and some offerings that are targeted at supplying particular dietary trends.

## 7.2. Energy Use

Energy is used in heating as part of the pasteurisation process and in drying milk to produce milk powder. Milk is largely water and the process to produce milk powder involves removing most of this water. The final stages are the most energy intensive; they involve air drying of concentrated milk which is sprayed into cone-shaped powder dryers.

Estimates of total energy demand are shown in Table 33; these are scaled up from Fonterra's total production to produce an estimate for the industry as a whole. The primary energy includes gas that is used for generation of electricity, some of which is exported to the grid. To estimate the total attributable to dairy processing activity, we take an estimate of total energy output from cogeneration (as GWhs of heat and electricity) and subtract a proportion of the gas that is attributable to generation of exported electricity. The quantities used to derive energy intensities and as the basis for future projections is the final column (Attributable energy purchases). This measures gas used in electricity generation rather than electricity consumption by the dairy industry.

**Table 33** Energy Use in Dairy Production (2008 estimates)

| Energy Demand | Primary energy | Input to cogen | Cogen Electricity output | Cogen Electricity Export | Energy Consumption[1] | Attributable energy purchases[2] |
|---|---|---|---|---|---|---|
| Gas (PJ) | 18.7 | 11.5 | | | 14.7 | 17.0 |
| Coal (PJ) | 7.9 | | | | 7.9 | 7.9 |
| Electricity (GWh) | 387 | | 960 | 400 | 947 | 387 |

[1] Excludes proportion of gas consumed in cogeneration attributable to electricity generation.

[2] Includes gas consumed in cogeneration plant to generate electricity, but excludes that attributable to electricity that is exported to grid

Source: Fonterra; Covec estimates

The coal used is a mixture of bituminous and sub-bituminous coals; we have assumed a 50:50 mix.

For forward projections it is useful to examine the implications of additional cogeneration and for that reason we examine demand for heat and electricity rather than simply as demand for the primary fuels. We use these to derive heat and electricity intensities.

Using assumptions about plant efficiencies, heat output is estimated from the estimates of fuel consumption. We combine these with estimates of heat plant capacities but these are not essential to the calculations given the starting point of energy consumption data—plant utilisation rates are used as balancing assumptions to ensure consistency of output estimates with capacity estimates. The estimates are shown in Table 34. It includes the estimates of attributable gas from cogen plants, ie exclusion that proportion that can be attributed to the production of electricity for sale to the grid.

**Table 34** Dairy Processing Energy Supply

| Plant | MW | Effici-ency | Output (PJ) | | Electr-icity | Input (PJ) | | |
|---|---|---|---|---|---|---|---|---|
| | | | Heat | Electr-icity | exports to grid | Gas (attributable) | Coal | Grid electricity |
| Cogen (Gas) | 180 | 85% | 6.3 | 3.5 | 1.4 | 11.5 (9.8) | | |
| Heat (Gas) | 255 | 75% | 5.4 | | | 7.2 | | |
| Heat (Coal) | 260 | 70% | 5.5 | | | | 7.9 | |
| Total | 875 | | 17.2 | 3.5 | 1.4 | 18.9 (17.0) | 7.9 | 1.4 |

Source: Fonterra; Covec estimates

These estimates are used to derive energy intensities as shown in Table 35; the energy intensities of production are estimated from 1.2 million tonnes of milksolids production. We assume for projections forward, that the Fonterra can be assumed across the industry as a whole.

**Table 35** Energy Intensities

| | Milksolids kt | Heat PJ | Electricity PJ (GWh) | Heat GJ/t | Electricity GJ/t (MWh/t) |
|---|---|---|---|---|---|
| South Island | 498 | 5.5 | | 11.0 | |
| North Island | 838 | 11.7 | | 14.0 | |
| NZ | 1,337 | | 3.4 (947) | | 2.6 (0.71) |

Source: Covec estimates from Fonterra data and projections

There appear to be reasonable prospects for improvements in energy efficiency for farmers and dairy companies alike. For example, Fonterra is currently working with the University of Waikato School of Science and Engineering to identify opportunities for Fonterra's milk powder plants to save energy.[68]

The most promising opportunities may lie in further use of co-generation plant, and in technological change in the drying process.

We link these energy intensities with activity projections below to provide an estimate of expected growth in demand. Historical activity data are shown in Table 36.

[68] University of Waikato. Waikato News 11 June 2008. University partners with Fonterra energy efficiency

**Table 36** Dairy Activity Data

| Year | North Island | | South Island | | New Zealand | |
|---|---|---|---|---|---|---|
| | Cows (millions) | Milksolids (kt) | Cows (millions) | Milksolids (kt) | Cows (millions) | Milksolids (kt) |
| 2000-01 | 2.74 | 839 | 0.75 | 257 | 3.49 | 1,096 |
| 2001-02 | 2.80 | 850 | 0.89 | 303 | 3.69 | 1,152 |
| 2002-03 | 2.78 | 862 | 0.96 | 329 | 3.74 | 1,191 |
| 2003-04 | 2.83 | 892 | 1.03 | 362 | 3.85 | 1,254 |
| 2004-05 | 2.80 | 849 | 1.06 | 363 | 3.87 | 1,213 |
| 2005-06 | 2.74 | 873 | 1.10 | 394 | 3.83 | 1,267 |
| 2006-07 | 2.76 | 894 | 1.16 | 422 | 3.92 | 1,316 |

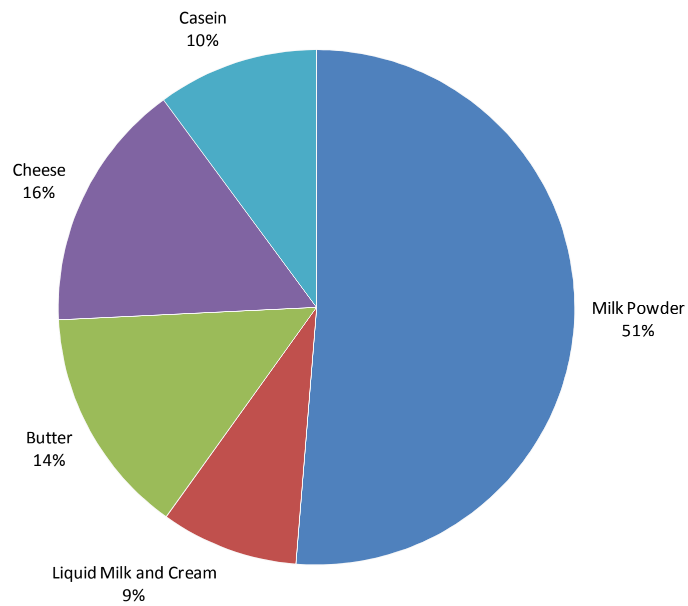
Source: Dairy NZ

## 7.3. Domestic and International Markets

### 7.3.1. International Markets

Fonterra exports 95% of its production and New Zealand supplies approximately one third of the internationally traded market for dairy products. As a result, the sector is a major contributor to New Zealand's international earnings, accounting for around 20% of the value of commodity exports. In the year to March 2008, the dairy sector exported goods worth NZ $10.5 billion; the exported products are shown in Figure 28 as percentages of export value.

**Figure 28** Dairy Export Product Mix (2007)




Source: Statistics NZ Infoshare. Export volume indexes and values

Prices for commodity exports vary considerably, while prices for branded products are higher (relative to cost) and more stable. Fonterra does operate several strong international brands, but sales are still dominated by commodities. Output markets for commodities are heavily influenced by support payments, particularly for European suppliers. High support payments bring forth greater supply and depress traded prices. Any progress towards reducing or eliminating these payments would be very beneficial for the New Zealand industry, though is obviously difficult for political reasons.

The New Zealand dairy industry is continually adjusting its output towards branded products that face relatively robust and inelastic demand. Combined with the chance that international support payments may lose political support, this suggests that the overall outlook for export returns to the New Zealand dairy industry is positive.

#### 7.3.2. Drivers of Net Market Demand for New Zealand Product

International prices for dairy products rose to very high levels in 2008 but are now declining. High prices were fuelled by demand growth particularly in China and OPEC nations and significant disruptions to supply, including drought in Australia and reforms to the EU Common Agricultural Policy (CAP) that led to a shift towards cheese production and away from powders.[69]

Current expectations of low or negative economic growth in many countries, is likely to lead to lower demand for dairy products and dairy payouts in New Zealand have been falling with commodity prices.

Nevertheless, milk production and manufactured exports are forecast to steadily increase. But production is expected to increase elsewhere also, including: [70]

- in the US from productivity changes-yields per cow;
- increases in EU milk production quotas—they were raised by 2 percent for the year ending 31 March 2009, equivalent to 19% of New Zealand's forecast production in the year to 31 May 2009;
- Expanding output in developing countries, particularly China, India and some South American countries.

International dairy prices are expected to continue falling back from the peaks achieved in early 2008. The weakening New Zealand dollar is not expected to fully compensate for these falls and, as a result, final payouts to farmers for the 2007/08 season (year to 31 May 2008) of $7.90/kg of milksolids[71] are expected to be $5.10/kg in 2009.[72]

However, over the medium run world demand for dairy products is expected to continue to grow, particularly in India and China. Supply is expanding elsewhere also, and much of this is occurring in low cost jurisdictions, such as South America and in the

---

[69] Ministry of Agriculture and Forestry (2008) Situation and Outlook for New Zealand Agriculture and Forestry (August 2008)

[70] Ministry of Agriculture and Forestry (2008) Situation and Outlook for New Zealand Agriculture and Forestry (August 2008)

[71] Fonterra Media Release 26 September 2008

[72] Fonterra media release 28th January 2009

territories of the former Soviet Republic. However, New Zealand is expected to see continued growth set against growing worldwide demand for dairy products.[73]

### 7.3.3. Domestic Markets

The domestic markets for dairy products are very small. They would be completely incapable of supporting an industry of anything like the current scale on their own. Depending on how the industry structure evolves in New Zealand, the domestic market may play more of a role as a pre-export testing ground.

### 7.3.4. Input Markets

The competitive position of the New Zealand dairy industry derives primarily from low cost supply of raw milk into the dairy companies. Costs of production in New Zealand are low relative to other exporting countries (Figure 29) but there are a number of emerging countries with low costs supplies.

**Table 37** Dairy Production Costs

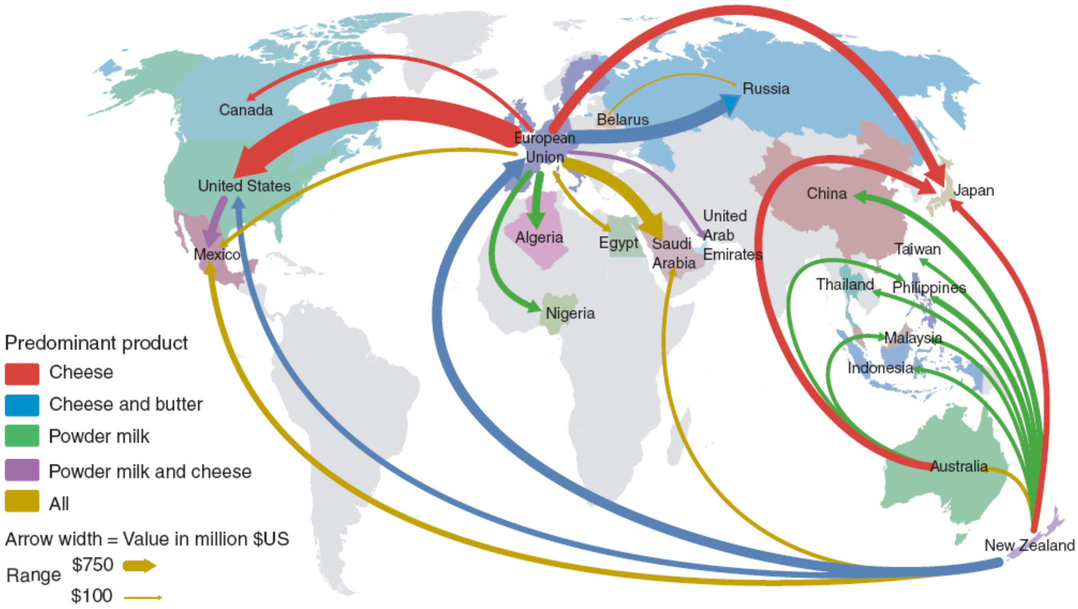
| Country | US Cents/kg (ECM)[1] |
|---|---|
| Argentina | 7.7 |
| India | 8.0 |
| Bangladesh | 11.0 |
| Poland | 11.0 |
| New Zealand | 12.0 |
| Brazil | 15.0 |
| The Netherlands | 15.5 |
| Australia | 16.0 |
| Chile | 18.0 |
| Ireland | 18.0 |

[1] Energy Corrected Milk (ECM): The average cost of production of a litre of milk, taking into account variations in fat content

Source: Fonterra. Facts & Figures (2007).

[73] Strong demand will of course only translate into sectoral growth if dairy maintains its current attraction to suppliers relative to their other land-use options.

**Figure 29** Major Global Trade Flows in Dairy Products (2003)




Source: Blayney DP and Gehlhar MJ (2005) U.S. Dairy at a New Crossroads in a Global Setting. Amber Waves, 3(5):32-37. US Department of Agriculture

## 7.4. Cut-Off Prices

Costs of dairy production are not published but some idea of the relative costs of energy for dairy processing can be estimated from the total energy demand and assumptions over energy prices. Cost estimates are provided in Table 38.

**Table 38** Dairy Energy Costs

| | Quantity | Unit | Quantity | Unit | $million |
|---|---|---|---|---|---|
| Milksolids (kt) | 1,337 | kt | 6 | $/kg | 8,021 |
| Gas | 17.0 | PJ | 7 | $/GJ | 119 |
| Coal | 7.9 | PJ | 6 | $/GJ | 47 |
| Electricity | 387 | GWh | 80 | $/MWh | 31 |
| Total energy cost | | | | | 197 |
| % of payout | | | | | 2% |

Energy costs are approximately 15 cents per kg of milk solids or 2.5% of dairy pay-out costs. It is unlikely that increasing energy prices will lead to significant reductions in dairy processing in New Zealand.

## 7.5. Energy and Greenhouse Gas Projections

### 7.5.1. Energy Projections

Energy projections are estimated using forward projections of cattle numbers and milksolids production. DairyNZ produces projections through to 2030 and these have been used as inputs to this study. We continue their trend projections through to 2035.

Table 39 shows estimates of energy demand through to 2035 under assumptions of no change in energy intensities of production. If we assume that ongoing improvements in efficiency of production are achieved, then energy demand will reduce. In Table 40 we show the results of an assumed 1% per annum improvement in energy (heat and electricity) demand.

**Table 39** Dairy Energy Projections

| | Milksolids (kt) | | | Electricity Own generation | Electricity Grid | Electricity Total | Electricity grid | Gas | Coal |
|---|---|---|---|---|---|---|---|---|---|
| | NI | SI | NZ | NI | NI | NI | SI | NI | SI |
| 2008 | 838 | 498 | 1,337 | 560 | 34 | 594 | 353 | 17.0 | 7.9 |
| 2009 | 879 | 550 | 1,428 | 560 | 63 | 623 | 390 | 17.8 | 8.7 |
| 2010 | 906 | 603 | 1,509 | 560 | 82 | 642 | 427 | 18.3 | 9.5 |
| 2011 | 913 | 647 | 1,561 | 560 | 87 | 647 | 459 | 18.4 | 10.2 |
| 2012 | 919 | 684 | 1,603 | 560 | 91 | 651 | 485 | 18.5 | 10.8 |
| 2015 | 923 | 803 | 1,725 | 560 | 94 | 654 | 569 | 18.6 | 12.6 |
| 2020 | 940 | 970 | 1,910 | 560 | 106 | 666 | 688 | 18.9 | 15.3 |
| 2025 | 943 | 1,086 | 2,029 | 560 | 109 | 669 | 769 | 19.0 | 17.1 |
| 2030 | 957 | 1,201 | 2,158 | 560 | 118 | 678 | 851 | 19.2 | 18.9 |
| 2035 | 967 | 1,342 | 2,309 | 560 | 125 | 685 | 951 | 19.4 | 21.1 |

**Table 40** Dairy Energy Projections with 1% pa Energy Efficiency Improvements

| | Milksolids (kt) | | | Electricity - own generation | Electricity Grid | Electricity Total | Electricity grid | Gas | Coal |
|---|---|---|---|---|---|---|---|---|---|
| | NI | SI | NZ | NI | NI | NI | SI | NI | SI |
| 2008 | 838 | 498 | 1,337 | 560 | 34 | 594 | 353 | 17.0 | 7.9 |
| 2009 | 879 | 550 | 1,428 | 560 | 56 | 616 | 386 | 17.6 | 8.6 |
| 2010 | 906 | 603 | 1,509 | 560 | 69 | 629 | 419 | 18.0 | 9.3 |
| 2011 | 913 | 647 | 1,561 | 560 | 68 | 628 | 445 | 17.9 | 9.9 |
| 2012 | 919 | 684 | 1,603 | 560 | 66 | 626 | 466 | 17.9 | 10.4 |
| 2015 | 923 | 803 | 1,725 | 560 | 49 | 609 | 530 | 17.4 | 11.8 |
| 2020 | 940 | 970 | 1,910 | 560 | 31 | 591 | 610 | 16.9 | 13.5 |
| 2025 | 943 | 1,086 | 2,029 | 560 | 4 | 564 | 648 | 16.2 | 14.4 |
| 2030 | 957 | 1,201 | 2,158 | 544 | 0 | 544 | 682 | 15.7 | 15.2 |
| 2035 | 967 | 1,342 | 2,309 | 522 | 0 | 522 | 725 | 15.1 | 16.1 |

### 7.5.2. Greenhouse Gas Projections

Greenhouse gas projections from dairy processing are estimated using the following emission factors for coal and gas:

- 52.6kt $CO_2$/PJ of gas based on a five year average of the national average gas emission factor for natural gas;[74] and

[74] MED (2008) New Zealand Energy Greenhouse Gas Emissions 1990-2007.

- 88.2kt for coal based on a 50:50 split between bituminous and sub-bituminous coals.[75]

Emission projections based on these emission factors and the energy demand data above are shown in Table 41.

**Table 41** Dairy Emissions Projections (kt)

| | No efficiency improvement | | | 1% per annum improvement | | |
|---|---|---|---|---|---|---|
| | NI gas | SI coal | NZ | NI gas | SI coal | NZ |
| 2008 | 896 | 692 | 1,589 | 896 | 692 | 1,589 |
| 2009 | 936 | 764 | 1,700 | 927 | 756 | 1,683 |
| 2010 | 963 | 837 | 1,800 | 945 | 821 | 1,766 |
| 2011 | 970 | 899 | 1,869 | 943 | 873 | 1,816 |
| 2012 | 975 | 950 | 1,926 | 940 | 913 | 1,853 |
| 2015 | 979 | 1,115 | 2,094 | 917 | 1,039 | 1,957 |
| 2020 | 996 | 1,348 | 2,344 | 891 | 1,195 | 2,086 |
| 2025 | 999 | 1,508 | 2,508 | 854 | 1,271 | 2,125 |
| 2030 | 1012 | 1,669 | 2,681 | 826 | 1,338 | 2,164 |
| 2035 | 1022 | 1,865 | 2,887 | 796 | 1,422 | 2,218 |

At 1.8 million tonnes from approximately 1.5 million tonnes of milksolids, this is equivalent to 1.2 tonnes of $CO_2$ from 1 tonne of milksolids. At $25 and $50/tonne of $CO_2$ this is equivalent to a cost of 3 cents and 6 cents per kg of milksolids respectively, or approximately 0.6 - 1.2% of this year's payout forecast of $5.10/kg.

The payout to farmers determines the raw material cost for production. Emission costs for dairy production can result in a reduced payout on the assumption that NZ producers of milk are price takers on the world market. In comparison with the emission impacts, the payout forecast has fallen by 90 cents per kg (from $6/kg to $5.10/kg) between November 2008 and January 2009, on the basis of lower projections of global demand. The emissions impact is small in comparison. This does not mean it will have no impact on milk production levels, particularly via land conversions to and/or away from dairy; the cumulative effect on top of the recent fall in value may be significant. But the other global economic factors are much more significant.

[75] Emission factors taken from MED (op cit)

# 8. Meat Processing

## 8.1. Introduction

Meat is a significant component of the New Zealand economy and its second-largest food export, worth NZ$4.4 billion in 2007; this is approximately 13% of total exports by value.[76] Beef ($1.6 billion) and sheep ($2.4 billion) are the major products. Other meat exports include venison, veal, goat, poultry, offal and co-products such as variety meats and sausage casings; animal-derived raw materials from New Zealand are also used in the pharmaceutical and natural medicine industries.[77]

Thermal energy, in the form of steam and hot water, is used for cleaning and sterilising and for rendering (heating meat products to produce meat meal and tallow).[78] Electricity is used for the operation of machinery and for refrigeration, ventilation, lighting and the production of compressed air.

## 8.2. Meat Processing

There are approximately 33 meat processors in New Zealand and 100 meat exporters. There has been increasing consolidation in processing since the mid-1990s; four major companies (PPCS, AFFCO, the Alliance Group and ANZCO Foods) are now supplying the majority of products. [79] There is a high degree of farmer ownership in meat processing companies. Farmers' cooperatives make up around 60% of New Zealand's sheep meat market and 35% of beef. Alliance and PPCS are both farmer-owned cooperatives. There are also a number of other privately owned and significant companies that control the balance of production.

## 8.3. Energy Demand

A survey of energy use in the meat industry was undertaken for the Meat Industry Association (MIA) in 2004. The results are shown in Table 42. This is the most comprehensive study of total energy use in the industry.

Forward projections of energy demand are based on projections of animal numbers and slaughter rates; we assume that energy use increases in proportion to slaughter rates.

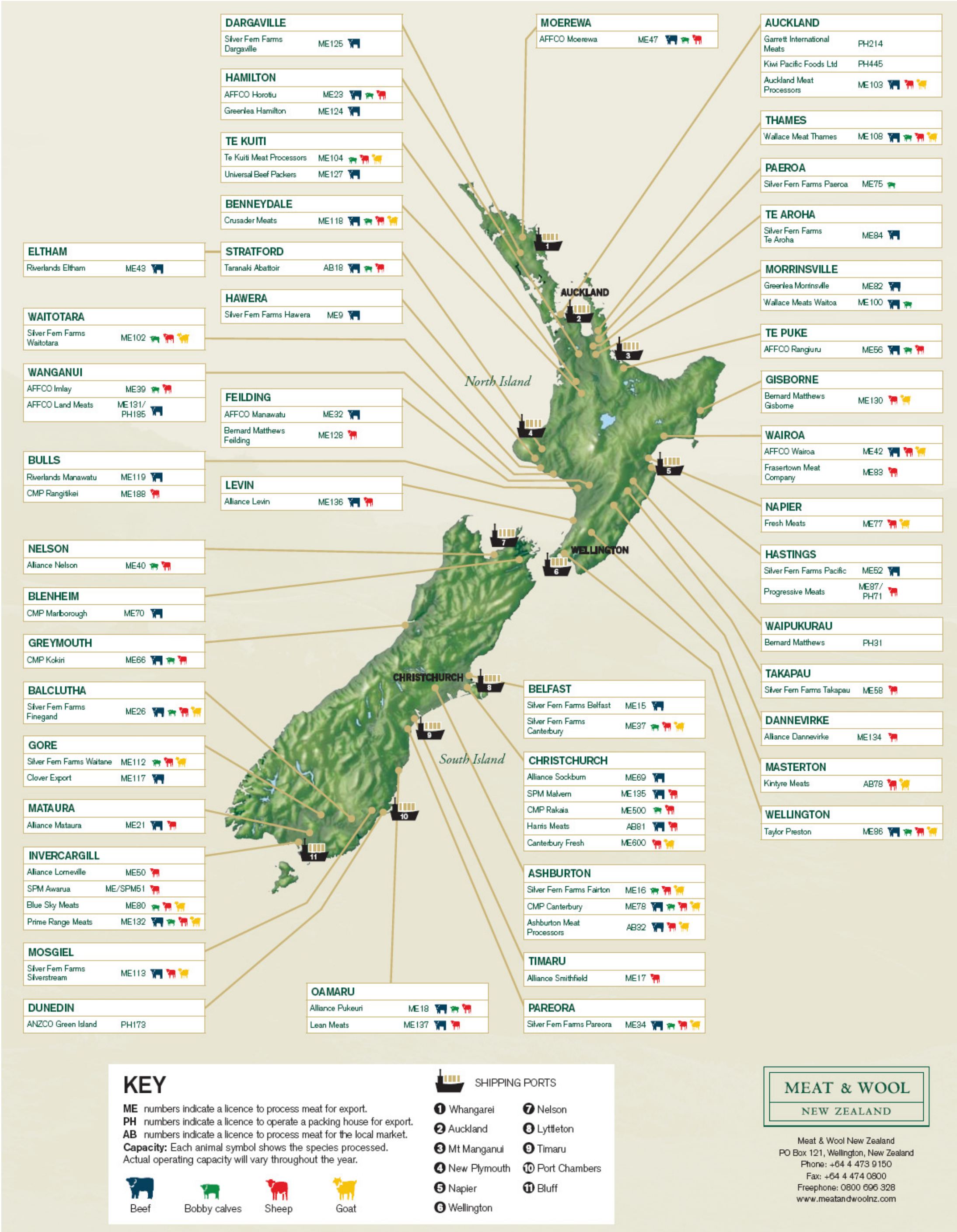
[76] StatsNZ

[77] New Zealand Trade & Enterprise (2007) New Zealand meat industry profile June 2007

[78] http://www.agrifood-forum.net/publications/guide/m_chp2.pdf

[79] NZTE (op cit)

**Figure 30** Meat Processing Plants in New Zealand (as at November 2008)




Source: Meat & Wool New Zealand (www.meatandwoolnz.com/main.cfm?id=345)

**Table 42** Energy use and Energy Intensity by the meat industry (2004)

| | North Island (TJ) | South Island (TJ) | Total (TJ) | North Island (GJ/t) | South Island (GJ/t) | Total (GJ/t) |
|---|---|---|---|---|---|---|
| Electricity | 1,202 | 1,095 | 2,297 | 1.56 | 2.49 | 1.90 |
| Coal[1] | 561 | 1,416 | 1,977 | 0.73 | 3.22 | 1.63 |
| Lignite | - | 1,010 | 1,010 | - | 2.30 | 0.83 |
| Natural gas | 1,726 | 14 | 1,741 | 2.24 | 0.03 | 1.44 |
| LPG | 66 | 33 | 98 | 0.09 | 0.07 | 0.08 |
| Fuel oil[2] | - | 26 | 26 | - | 0.06 | 0.02 |
| Total | 3,556 | 3,594 | 7,150 | 4.61 | 8.17 | 5.91 |
| Meat processed (kt) | 771.0 | 439.7 | | | | |

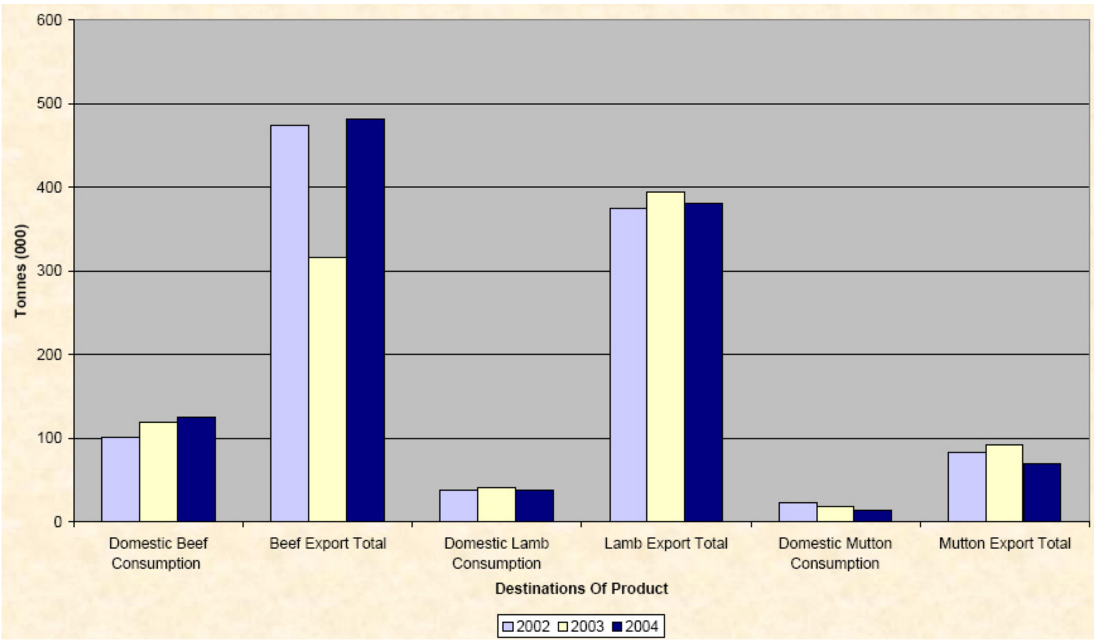
[1] Survey data were in tonnes; it is assumed to be bituminous coal with an energy content of 28.84MJ/kg; [2] data expressed in litres – it is assumed that the fuel oil is split 50:50 between light and heavy fuel oil with an average energy content of 40.79MJ/litre

Source: Meat Industry Association

## 8.4. Domestic and International Markets

Meat production is very largely for export markets. According to the Meat Industry Association, there is no regular collection of data on sales of meat on the domestic market, nor of any food items.[80] However, 2004 data suggest that domestic sales were 21% by tonnage for beef, 17% for mutton and 9% for lamb;[81] Figure 31 shows the results for 2002-04.

**Figure 31** Product Destinations for Meat



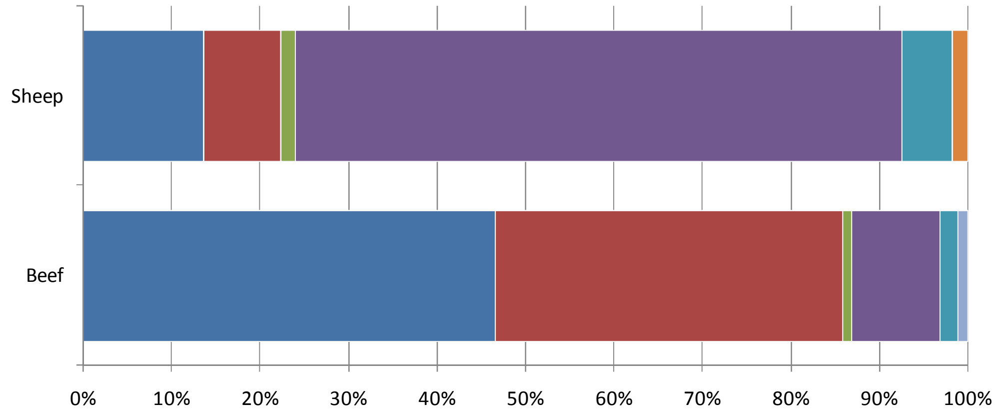

Source: Meat Industry Association (www.mia.co.nz/statistics/)

[80] Dan Coup, personal communication

[81] Meat Industry Association (www.mia.co.nz/statistics/)

The major international markets are shown in Figure 32.

**Figure 32** Export Markets for Sheep Meat and Beef




| | Beef | Sheep |
|---|---|---|
| North America | 47% | 14% |
| Asia | 39% | 9% |
| Oceania | 1% | 2% |
| Europe | 10% | 69% |
| Middle East | 2% | 6% |
| Africa | | 2% |
| Other | 1% | |

Source: Statistics New Zealand in: Meat Industry Association Annual Report 2008

New Zealand is the world's largest sheep meat exporter; in 2007 it accounted for a third of the world's sheep meat exports although from only 45 of the world's sheep meat production.[82] The UK remains the largest export market, 22% by weight in the year to the end of May 2008; France and Germany combined made up an additional 13%.

Beef exports are smaller in value than sheep meat and New Zealand's share of global volumes is smaller. The USA is New Zealand's largest export market for beef, at 41% of the total value, with Asia (particularly Japan, Korea, Taiwan and Malaysia) a slightly smaller 39%.

The meat industry has faced some difficulties in recent years from drought, high NZ dollar values, and levels of dairy conversion. Recent falls in exchange rate have eased pressure but this is combine currently with falling global economic activity and demand for a wide range of export commodities. Sheet meat export volumes have risen recently because of significant levels of conversion to dairy and stock has been "liquidated." However, prices have not been maintained as a result; in the 2007/08 year there was an 11% increase in export sales by volume but only a 4% increase in value.[83] China is increasing its demand for sheep meat but is also increasing levels of domestic supply.

[82] Meat Industry Association Annual Report 2008

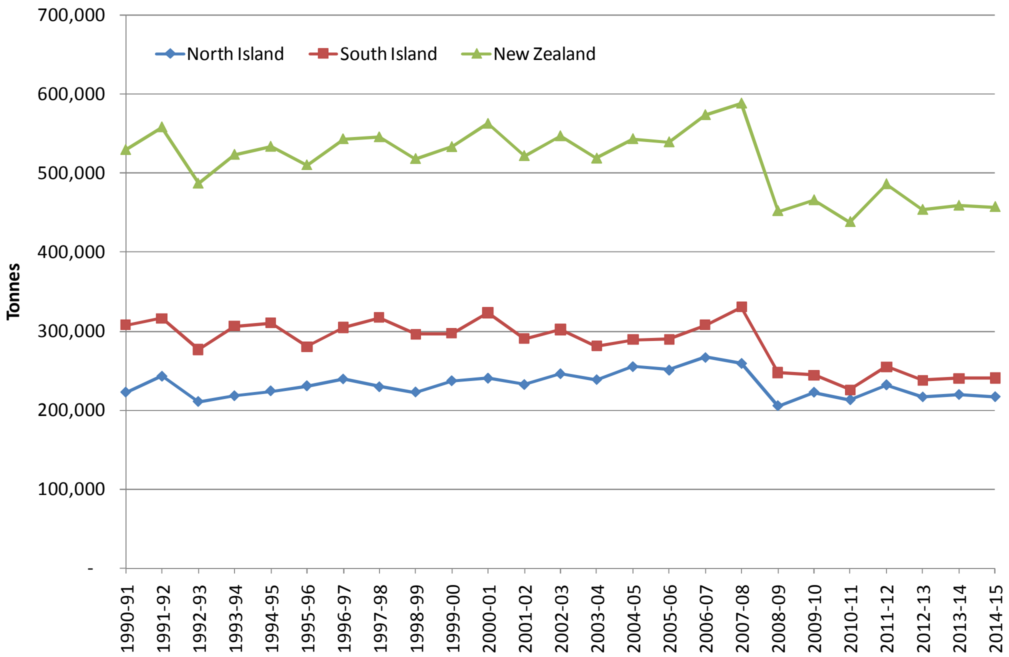
[83] MIA op cit

## 8.5. Projections of Energy and Greenhouse Gas Emissions

### 8.5.1. Activity Projections

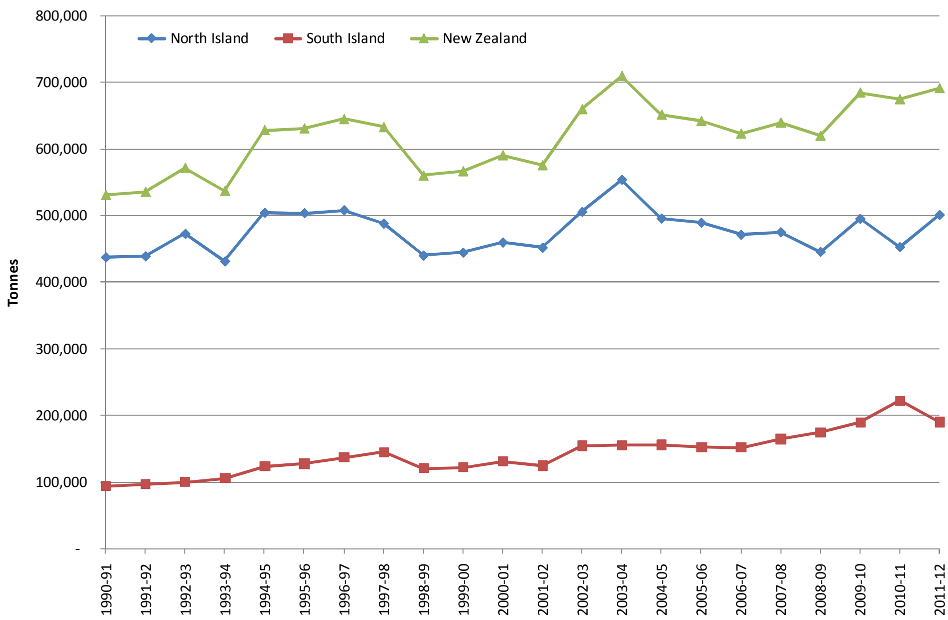
Figure 33 shows historical (to 2007/08) and projected quantities of sheep meat processed in meat works, separated by Island; the projections are produced by the Meat and Wool NZ Economic Service. Figure 34 shows the same data for cattle and veal production.

**Figure 33** Sheep Meat Production




Source: StatsNZ; Meat and Wool Economic Service

**Figure 34** Veal and Cattle - Tonnes of Graded Production



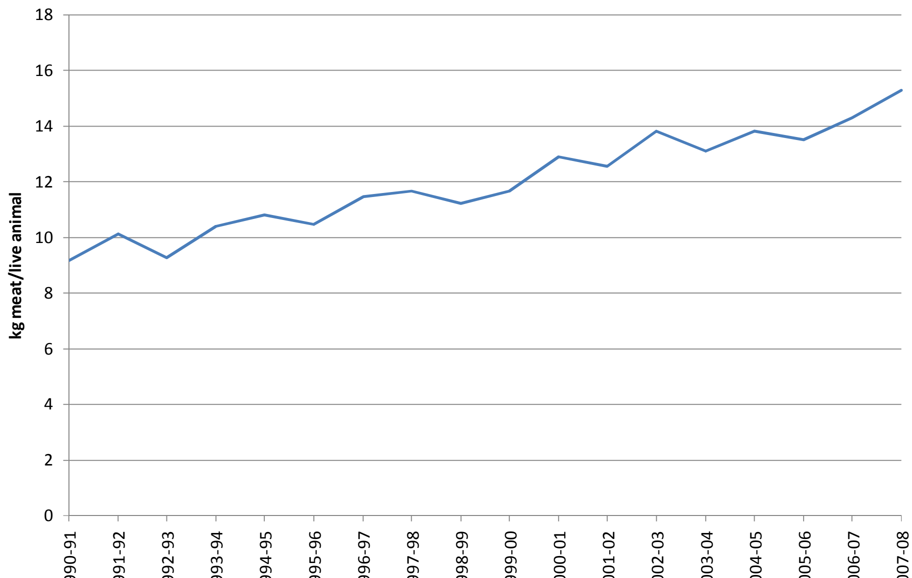

Source: StatsNZ; Meat and Wool Economic Service

There appears to be no real consensus in the industry on what will happen to production numbers in the longer term future, given two factors that have different impacts:

- the increasing shift of land towards dairy production; and
- increasing global demand for sheep meats and beef.

And the analysis of historical data is complicated by the current trend towards dairy that is resulting in increasing levels of slaughter as existing stocks are liquidated. In Figure 35 we show the quantities of meat produced per live animal; this is increasing over time not because of an increasing weight of animals but because a greater proportion of the stock is being slaughtered each year as the stock is run down. The issue is different for beef production, partly because dairy cattle are used to produce meat.

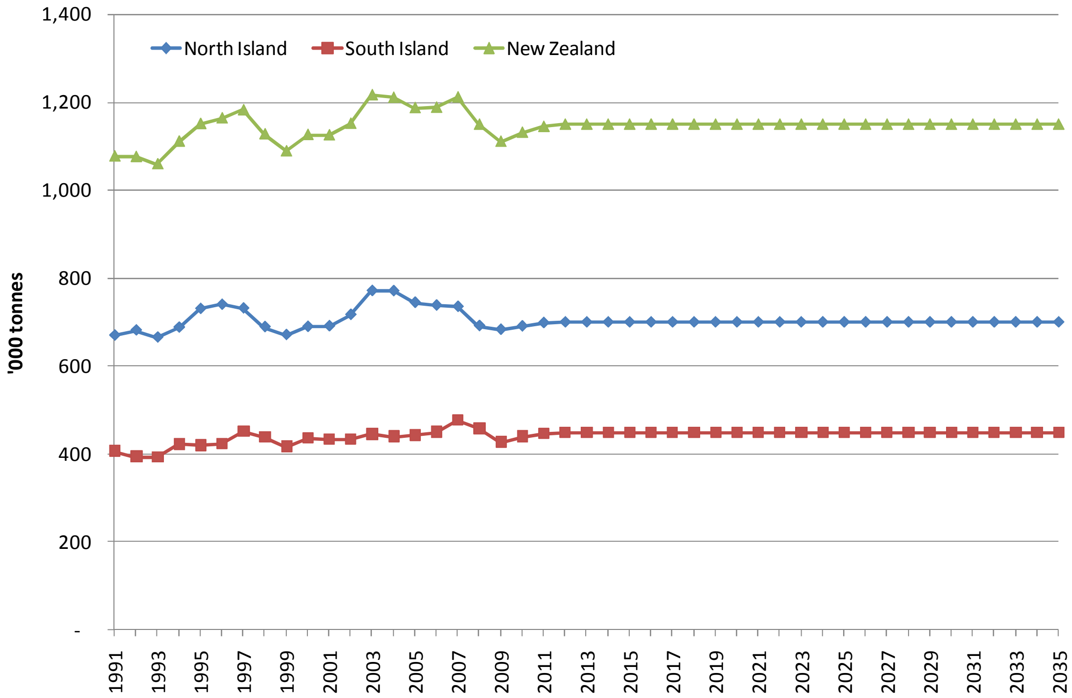
**Figure 35** Sheep meat production per head of live animals




Projections of sheep meat and beef production levels requires a detailed assessment of land use change, including the interaction between dairy, sheep & beef and other land uses. This kind of modelling is beyond the scope of this study. And its complexities mean that no other long run projections have been identified either. Our approach is thus simple. We have based our forward projections on those of Sheep & Wool NZ and used a five year average as the basis for a constant forward projection.

We then compare production data in 2004 with the energy demand and use this as the basis for estimating energy demand into the future. There is some scope for improvements in energy efficiency in the meat production sector but the potential is likely to be less than the margin of error in the production data projections.

**Figure 36** Tonnes of Meat Production




Note: the projected data are straight line projections from 2011. To that date we use NZStats historical data and Meat and Wool NZ projections to 2011.

Combining the historical data produces the energy intensities of production shown in Table 43. It suggests that energy intensities are much greater in the South Island than the North, possibly reflecting the different fuel types.

**Table 43** Energy Intensity of Production (GJ/tonne)

| | NI | SI | Total |
|---|---|---|---|
| Electricity | 1.56 | 2.49 | 1.90 |
| Coal | 0.73 | 3.22 | 1.63 |
| Lignite | - | 2.30 | 0.83 |
| Natural gas | 2.24 | 0.03 | 1.44 |
| LPG | 0.09 | 0.07 | 0.08 |
| Fuel oil | - | 0.06 | 0.02 |
| Total | 4.61 | 8.17 | 5.91 |

### 8.5.2. Energy Demand and Greenhouse Gas Projections

Using these energy intensities and the projected activity data, Table 44 shows projected energy demand to process the meat produced. It includes estimated greenhouse gas emissions based on emission factors in Table 45.

**Table 44** Energy Demand Projections (TJ)

| | Kt meat | Electricity | Coal | Lignite | Natural gas | LPG | Fuel oil | Total | $CO_2$ (kt) |
|---|---|---|---|---|---|---|---|---|---|
| 2008 | 1,187 | 2,218 | 1,977 | 1,051 | 1,564 | 93 | 27 | 6,931 | 365 |
| 2009 | 1,188 | 2,129 | 1,872 | 981 | 1,545 | 90 | 25 | 6,642 | 348 |
| 2010 | 1,212 | 2,173 | 1,919 | 1,010 | 1,562 | 92 | 26 | 6,782 | 356 |
| 2015 | 1,149 | 2,210 | 1,956 | 1,032 | 1,582 | 93 | 27 | 6,901 | 363 |
| 2020 | 1,149 | 2,210 | 1,956 | 1,032 | 1,582 | 93 | 27 | 6,901 | 363 |
| 2025 | 1,149 | 2,210 | 1,956 | 1,032 | 1,582 | 93 | 27 | 6,901 | 363 |
| 2030 | 1,149 | 2,210 | 1,956 | 1,032 | 1,582 | 93 | 27 | 6,901 | 363 |
| 2035 | 1,149 | 2,210 | 1,956 | 1,032 | 1,582 | 93 | 27 | 6,901 | 363 |

**Table 45** Emission factors (t $CO_2$/TJ)

| Coal | Lignite | Natural gas | LPG | Fuel oil |
|---|---|---|---|---|
| 88.8 | 95.2 | 52.6 | 60.4 | 72.0 |

## 8.6. Cut-Off Prices

As for the analysis of dairy production, in the absence of information on production costs, the value of output is compared here with the costs of energy. MAF estimates the 2008 value of lamb exports at approximately $3.42/kg and manufacturing beef at $2.25/kg.[84]

For comparison, Table 46 shows the costs of energy in meat production. It suggests energy costs of approximately $66/tonne or 7cents/kg. This is 1.9% of the value of sheep meat output and 3.0% of the value of beef output. The costs of emissions would be additional under an emissions trading system; total emissions are approximately 0.3 tonnes of $CO_2$ per tonne of meat, or a cost of $8 or $16/tonne at emission costs of $25 and $50/tonne respectively. This is 0.2-0.5% of the value of sheep meat or 0.4 – 0.7% of the value of beef.

**Table 46** Energy costs in production

| | GJ/t | Price | Cost ($/tonne) |
|---|---|---|---|
| Electricity | 0.53 (MWh/t) | 80 | 42.16 |
| Coal | 1.63 | 6 | 9.80 |
| Lignite | 0.83 | 2 | 1.67 |
| Natural gas | 1.44 | 8 | 11.50 |
| LPG | 0.08 | 12 | 0.98 |
| Fuel oil | 0.02 | 16 | 0.35 |
| Total | 5.91 | | 66.45 |

84 MAF (2008) Situation and Outlook for New Zealand Agriculture and Forestry.

It is unlikely that expected changes in energy costs, including those associated with the ETS, will have an impact on continued meat production in New Zealand.

# 9. Timber Processing

## 9.1. Introduction

The forestry processing sector includes pulp & paper production, sawmilling and panels production. The sector is currently made up of four significant players; Carter Holt Harvey, Norske Skog, Pan Pac and Winstone Pulp with a number of other smaller players. The majority of energy use in the sector is in pulp and paper production (78%), with approximately 13% in panels and 9% in sawmills.

## 9.2. Industry Outlook

Wood products are the third largest export earner behind dairy and meat. Total export earnings from wood products for the year ended June 2008 were $2.9 billion, 7% less than the year to June 2007.[85] The main markets for wood products are Australia, North Asia and the US. Increasing amounts are being exported to China, the US, Vietnam and India; exports to Japan are decreasing.[86]

The high New Zealand dollar has affected returns and thus levels of investment. The dollar has recently reduced in value but this coincides with reductions in global demand for all commodities. MAF forecasts that "the total forestry export value will remain flat with log markets potentially more positive than processed wood products. These market conditions have already triggered significant rationalisation within the wood processing sector, which is likely to continue for some time particularly among smaller and older processing facilities."[87]

Table 47 shows MAF's projections of export prices, volumes and values to 2012.

**Table 47** Forestry export prices, volumes and value, 2005–2012

| Year to 31 March | | | | Actual | | | | Forecast |
|---|---|---|---|---|---|---|---|---|
| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
| **Logs and chips** | | | | | | | | |
| FOB price ($ per m$^3$) | 78 | 84 | 104 | 95 | 103 | 112 | 121 | 128 |
| Export volume ('000 m$^3$) | 5,649 | 5,753 | 6,561 | 7,070 | 7,423 | 7,736 | 7,891 | 8,049 |
| **Timber** | | | | | | | | |
| FOB price ($ per m$^3$) | 438 | 396 | 415 | 410 | 390 | 415 | 454 | 488 |
| Export volume ('000 m$^3$) | 1,847 | 1,818 | 1,939 | 1,773 | 1,690 | 1,694 | 1,728 | 1,762 |
| **Panels** | | | | | | | | |
| FOB price ($ per m$^3$) | 511 | 451 | 454 | 474 | 441 | 486 | 535 | 575 |
| Export volume ('000 m$^3$) | 1,132 | 1,125 | 994 | 920 | 904 | 920 | 929 | 938 |
| **Pulp** | | | | | | | | |
| FOB price ($/tonne) | 585 | 559 | 734 | 705 | 755 | 825 | 899 | 966 |
| Export volume ('000 tonnes) | 839 | 854 | 810 | 866 | 901 | 919 | 928 | 937 |
| **Total forestry export value ($ mil)** | 3,255 | 3,164 | 3,548 | 3,397 | 3,434 | 3,810 | 4,220 | 4,580 |

Source: MAF (2008) Situation and Outlook for Agriculture and Forestry 2008

[85] MAF (2008) Briefing for Incoming Ministers

[86] MAF (op cit)

[87] MAF (op cit)

New Zealand's competitive position has been in the productivity of its plantation forests and in relatively low energy costs. Energy costs have been rising and returns to plantation forestry have fallen, particularly in comparison with other land uses. The emissions trading system has, in addition, introduced some uncertainties and additional risks in forestry investments.

Our projections of future activity are consistent with the MAF assessments; this includes a flat forward projection of activity in pulp and paper production, and for panels. The difficulty is in projecting activity in sawmilling. Quantities of harvested timber are expected to rise steadily over the next 15 years or so from plantations planted 25-30 years ago (see Figure 38 below). These additional volumes might conceivably be used to produce sawn timber as the simplest, and lowest capital cost, production option. However, in recent years there have been several plant closures, particularly in response to rising energy costs and the, until recently, high NZ dollar value. There is the additional recent issue of declining demand from the construction industry, both in New Zealand and in export markets. The alternative is for additional volumes of harvested timber to be exported as logs or used as inputs to alternative uses of wood, eg biomass fuel.

The reality is that future production levels are highly uncertain. We have tended towards conservative projections based on continuing production rates at recent levels.

## 9.3. Pulp and Paper

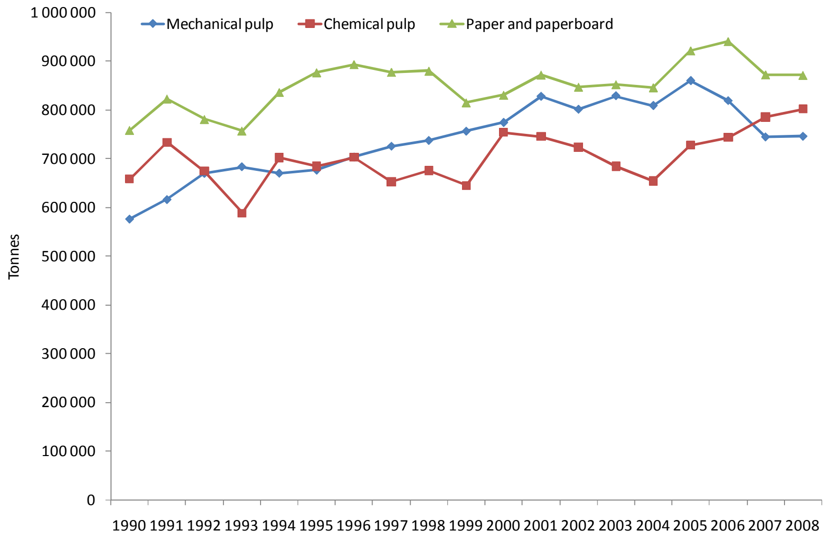
There are two main types of pulp:[88]

- **Chemical** which includes
  - **Chemical**—Wood chips are fully "cooked" with chemicals to dissolve the lignin that binds fibres. The yield from chemical pulping is 50% as the lignin is used to produce process energy.
  - **Semi-chemical**—Wood chips are partially cooked with chemicals and separated by mechanical refining. Yields range between 60% and 90%.
- **Mechanical**—Wood chips are separated into fibres by mechanical refining and here the yield can be up to 96%.

Annual pulp production in New Zealand is currently (year to 31 March 2008) approximately 1.5 million tonnes, including approximately 0.75 million tonnes of mechanical pulp and 0.8 million tonnes of chemical pulp; production of paper and paperboard is an additional 0.87 million tonnes (Figure 37).

[88] Gifford J and Anderson CJ (2003) NZ Forest Research. Energy Use in the Wood Processing Industry. New Zealand Forest Research Institute Ltd

**Figure 37** Production of Pulp and Paper




Source: www.maf.govt.nz/statistics/primaryindustries/forestry/production/annual-pulp-and-paper-highlight/index.htm

There is an installed capacity of approximately 2 million tonnes of pulp and paper plants in New Zealand (Table 48) with a total energy demand of approximately 30PJ.

**Table 48** Current Pulp & Paper Capacity, Production and Energy Use

| | Capacity | Production | | Energy intensity | | Energy demand | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pulp | Paper | Heat | Electricity | Heat | Electricity | Electricity | Total |
| | `000 Adt pa | `000 Adt pa | `000 Adt pa | GJ/Adt | kWh/Adt | PJ | GWh | PJ | PJ |
| **CHH** | | | | | | | | | |
| Kinleith Chemical pulp | 475 | 475 | | 16.2 | 770 | 7.7 | 366 | 1.32 | 9.0 |
| Kinleith paper | 325 | | 325 | 6.8 | 715 | 2.2 | 232 | 0.84 | 3.0 |
| Kawerau chemical pulp | 275 | 275 | | 14.5 | 740 | 4.0 | 204 | 0.73 | 4.7 |
| Whakatane paper | 115 | | 115 | 7 | 1150 | 0.8 | 132 | 0.48 | 1.3 |
| Penrose paper | 75 | | 75 | 5.2 | 550 | 0.4 | 41 | 0.15 | 0.5 |
| TOTAL | 1265 | 750 | 515 | | | 15.1 | 975 | 3.51 | 18.6 |
| **Norske Skog** | | | | | | | | | |
| Kawerau mill + paper | 300 | | 300 | 15 | 3200 | 4.5 | 960 | 3.46 | 8.0 |
| **Winstones** | | | | | | | | | |
| Mechanical mill | 150 | 140 | | 2.1 | 1850 | 0.3 | 259 | 0.93 | 1.2 |
| **Pan Pac** | | | | | | | | | |
| Mechanical mill | 260 | 230 | | 2.1 | 2200 | 0.5 | 506 | 1.82 | 2.3 |
| TOTAL | 1,975 | 1,120 | 815 | | | 20.4 | 2,700 | 9.7 | 30.1 |

Source: forestry companies

The supply of energy from on-site generation to meet this demand is estimated in Table 49.

Total energy required to meet this demand, including on-site and purchased energy, is set out in Table 50.

We have assumed no future change in energy efficiency and that these levels of energy demand continue. Pulp and paper production appears to be relatively static currently.

It adds to a total of 81PJ. The largest consumption, at 48.5 PJ, is of geothermal energy; however, this is largely because of the assumed 15% efficiency of conversion assumed by MED.[89] Final energy from geothermal is only 5.1PJ.A further 20.9 PJ is from biomass sources, ie use of wood wastes.

**Table 49** Energy Output of Plants Owned by Pulp & Paper Industry

| | | | | Heat output | | Electric output | | Total output | |
|---|---|---|---|---|---|---|---|---|---|
| | Capacity (MW) | Efficiency | Utilisa tion | GWh | PJ | GWh | PJ | GWh | PJ |
| **Kinleith** | | | | | | | | | |
| Cogen | 80 | 80% | 83% | 322 | 1.2 | 263 | 0.9 | 585 | 2.1 |
| Lime kiln | 35 | | 90% | 276 | 1.0 | | | 276 | 1.0 |
| Gas boilers | 50 | 70% | 83% | 366 | 1.3 | | | 366 | 1.3 |
| Boilers | 280 | 70% | 90% | 2208 | 7.9 | | | 2208 | 7.9 |
| Total | 445 | | | 3171 | 11.4 | 263 | 0.9 | 3434 | 12 |
| **Kawerau** | | | | | | | | | |
| Cogen | 40 | 80% | 90% | 189.2 | 0.7 | 126.1 | 0.5 | 315 | 1.1 |
| Lime kiln | 20 | | 90% | | | | | 158 | 0.6 |
| Recovery Boiler | 140 | 70% | 90% | 1140 | 3.8 | | | 1104 | 4.0 |
| Geothermal heat | 170 | 15% | 90% | 1340 | 4.8 | | | 1340 | 4.8 |
| Geothermal elec | 8.5 | 15% | 90% | | | 67 | 0.2 | 67 | 0.2 |
| MRP electric | 100 | 15% | 70% | | | 613 | 2.2 | 613 | 2.2 |
| Total | 478.5 | | | 2633 | 9.5 | 806 | 2.9 | 3597 | 13.0 |
| **Whakatane** | | | | | | | | | |
| Boilers | 35 | 70% | 70% | 215 | 0.8 | | | 215 | 0.8 |
| **Winstones** | | | | | | | | | |
| Cogen | 42 | 80% | 75% | 193.2 | 0.7 | 83 | 0.3 | 276 | 1.0 |
| **PanPac** | | | | | | | | | |
| Boiler | 10 | 70% | 85% | 74 | 0.3 | | | 74 | 0.3 |
| Cogen | 16 | 80% | 85% | 59.6 | 0.2 | 60 | 0.2 | 119 | 0.4 |
| Total | 26 | | | | | | | | |
| Total | 860 | | | 6,166 | 22 | 1,070 | 4.0 | 7,393 | 27 |

Source: forestry companies

We have assumed no change in energy efficiency going forward and that these levels of energy demand continue into the future. Pulp and paper production appears to be relatively static currently.

[89] MED (2008) Energy Data File June 2008

**Table 50** Fuel use in energy production

| | Fuel use (%) | | | | | | Fuel use (PJ) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wood waste | Black liquor | Gas | Fuel oil | Coal | Geo | Wood waste | Black liquor | Gas | Fuel oil | Coal | Geo | Grid elec & heat |
| **Kinleith** | | | | | | | | | | | | | |
| Cogen | 60% | | 40% | | | | 1.6 | | 1.1 | | | | |
| Lime kiln | | | 70% | 30% | | | | | 0.7 | 0.3 | | | |
| Gas boilers | | | 100% | | | | | | 1.9 | | | | |
| Boilers | | 100% | | | | | | 11.4 | | | | | |
| Total | | | | | | | 1.6 | 11.4 | 3.6 | 0.3 | | | 1.21 |
| **Kawerau** | | | | | | | | | | | | | |
| Cogen | 90% | | | 10% | | | 1.3 | | | 0.1 | | | |
| Lime kiln | | 100% | | | | | | | | | | | |
| Recovery Boiler | | | | | | 100% | | 5.7 | | | | 32.2 | |
| Geothermal heat | | | | | | 100% | | | | | | 1.6 | |
| Geothermal electricity | | | | | | 100% | | | | | | 14.7 | |
| Total | | | | | | | 1.3 | 5.7 | | 0.1 | | 48.5 | 1.3 |
| **Whakatane** | | | | | | | | | | | | | |
| Boilers | | | | | 100 % | | | | | | 1.1 | | 0.5 |
| **Penrose** | | | | | | | | | | | | | 1.0[1] |
| **Winstones** | | | | | | | | | | | | | |
| Cogen | 100% | | | | | | 0.4 | | | | | | 0.9 |
| **PanPac** | | | | | | | | | | | | | |
| Boiler | 80% | | 20% | | | | 0.3 | | 0.08 | | | | |
| Cogen | 80% | | 20% | | | | 0.4 | | 0.11 | | | | |
| Total | | | | | | | 0.7 | | 0.18 | | | | 1.7 |
| Total | 8% | 29% | 6% | | 0% | 57% | 3.9 | 17.0 | 3.8 | 0.4 | 1.1 | 48.5 | 6.5[1] |

[1] includes 0.8PJ of heat from Southdown

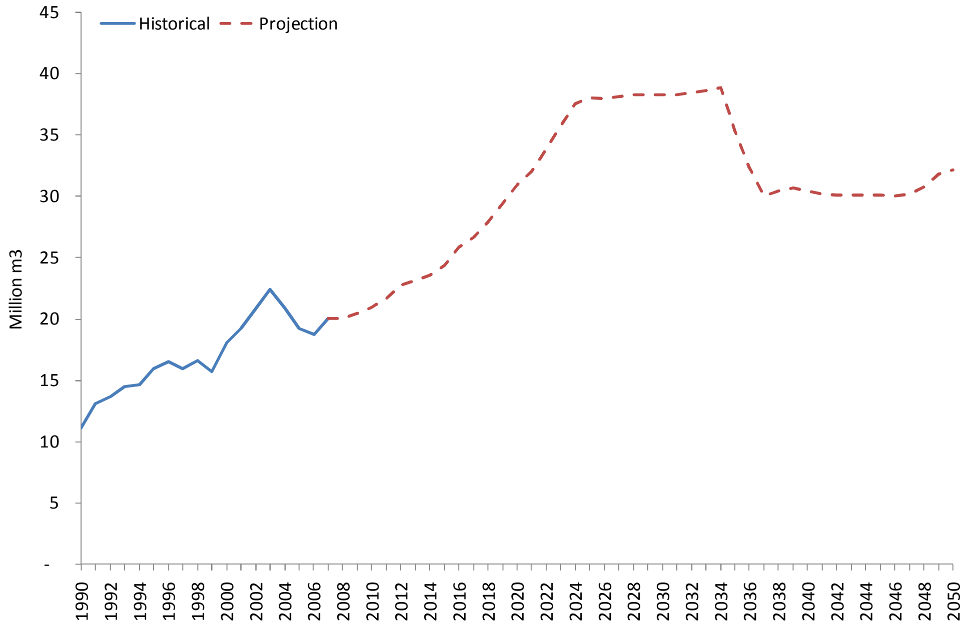
Source: forestry companies

## 9.4. Sawmilling

The total timber input to sawmills is dependent on a combination of wood supply, production costs and the relative value of sawn timber and other products, including logs. Currently demand for sawn timber is reduced because of the slump in the property market. However, this is unlikely to persist over the forecast period. However, despite projections of rising total wood availability (Figure 38), recent sawmill closures suggest there is a lack of industry confidence in the prospects for New Zealand sawn timber production.

There is no real industry consensus on future prospects and we adopt a conservative approach that maintains production levels approximately equal to recent levels of production.

**Figure 38** Projections of Wood Availability




Source: MAF

Current plant capacity is for production of approximately 5.4 million $m^3$.[90]

In 2002, primary energy demand for sawmilling was 8.1PJ to produce 3.86 million $m^3$ of rough sawn timber, an average energy intensity of 2.1 GJ/$m^3$.[91] Energy demand is largely for timber drying; 6.3PJ was used to produce 1.9 million $m^3$ of dried timber. NZFRI[92] examined energy intensities in timber drying and found a huge range via an industry survey, from less than 1GJ/$m^3$ to over 26 GJ/$m^3$, with an average of 2.9 GJ/$m^3$.

Wood residues are the main energy sources for drying and are increasing over time; biomass for drying represents 63% of total energy demand for sawmilling (Table 51). The amount of sawn timber that is dried has increased over time and is currently over 50%; industry expectations are that virtually all sawn timber will be dried in the future.[93] A key question is whether this increased drying demand will be met by biomass (wood waste) or will require increased use of coal and gas.

For modelling we use the energy intensity of drying noted above (2.9GJ/$m^3$) and increase the proportion that is dried over time. The energy intensity of other components of sawmilling is estimated using an average intensity based on the non-drying energy use in 2002 (1.8 PJ) divided by the production quantity (3.86 million $m^3$), ie 0.47 GJ/$m^3$.

[90] 2004 data; MAF

[91] Gifford J and Anderson CJ (2003) NZ Forest Research. Energy Use in the Wood Processing Industry. New Zealand Forest Research Institute Ltd

[92] Gifford and Anderson (op cit)

[93] Gifford and Anderson (op cit)

**Table 51** Energy Use in Sawmilling Sector (PJ)

| Energy Source | 1995 | 1997 | 2002 | 2002 (%) |
|---|---|---|---|---|
| Biomass | 1.18 | 0.47 | 5.0 | 63% |
| Electricity | 0.40 | 0.50 | 0.9 | 11% |
| Fuel Oil | 0.26 | 0.24 | 0.0 | 0% |
| Coal | - | 0.25 | 0.3 | 4% |
| Natural gas | 0.80 | 1.31 | 1.0 | 12% |
| LPG | - | - | 0.3 | 4% |
| Petrol | - | - | 0.0 | 0% |
| Geothermal | 0.20 | - | 0.5 | 6% |
| **Total** | 2.84 | 2.77 | 8.1 | 100% |

Source: Gifford J and Anderson CJ (2003) NZ Forest Research. Energy Use in the Wood Processing Industry

Projected energy consumption (demand) is shown in Table 53. Fuel use to meet this demand is shown in Table 52.

**Table 52** Projected Energy Consumption by Sawmills (PJ)

| Year | Biomass | Coal | Gas | Electricity | Diesel | Geothermal | LPG | TOTAL |
|---|---|---|---|---|---|---|---|---|
| 2007 | 5.8 | 0.3 | 1.2 | 1.0 | 0.1 | 0.5 | 0.3 | 9.3 |
| 2008 | 5.5 | 0.3 | 1.1 | 0.9 | 0.1 | 0.5 | 0.3 | 8.8 |
| 2009 | 5.6 | 0.3 | 1.1 | 0.9 | 0.1 | 0.5 | 0.3 | 8.9 |
| 2010 | 5.7 | 0.3 | 1.1 | 0.9 | 0.1 | 0.5 | 0.3 | 9.0 |
| 2015 | 6.2 | 0.4 | 1.2 | 0.9 | 0.1 | 0.5 | 0.3 | 9.6 |
| 2020 | 6.6 | 0.4 | 1.3 | 0.9 | 0.1 | 0.5 | 0.3 | 10.2 |
| 2025 | 7.1 | 0.4 | 1.4 | 0.9 | 0.1 | 0.5 | 0.3 | 10.8 |
| 2030 | 7.4 | 0.4 | 1.5 | 0.9 | 0.1 | 0.5 | 0.3 | 11.1 |
| 2035 | 7.4 | 0.4 | 1.5 | 0.9 | 0.1 | 0.5 | 0.3 | 11.1 |

**Table 53** Projected Primary Energy Consumption by Sawmills (PJ)

| | Sawmill | | | | | | Fuel split | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Production | | Energy in drying | | Energy other | | Drying | | | Other | | | |
| | 000m3 | % dried | GJ/m3 | PJ | GJ/m3 | PJ | Biomass | Coal | Gas | Electricity | Diesel | Geothermal | LPG |
| 2007 | 4, 280 | 59% | 2.9 | 7.32 | 0.46 | 1.97 | 79.4% | 4.8% | 15.9% | 50.0% | 5.6% | 27.8% | 16.7% |
| 2008 | 4, 014 | 60% | 2.9 | 6.98 | 0.46 | 1.85 | 79.4% | 4.8% | 15.9% | 50.0% | 5.6% | 27.8% | 16.7% |
| 2009 | 4,425 | 61% | 2.9 | 7.83 | 0.46 | 2.04 | 79.4% | 4.8% | 15.9% | 50.0% | 5.6% | 27.8% | 16.7% |
| 2010 | 4,000 | 62% | 2.9 | 7.19 | 0.46 | 1.84 | 79.4% | 4.8% | 15.9% | 50.0% | 5.6% | 27.8% | 16.7% |
| 2015 | 4,000 | 67% | 2.9 | 7.77 | 0.46 | 1.84 | 79.4% | 4.8% | 15.9% | 50.0% | 5.6% | 27.8% | 16.7% |
| 2020 | 4,000 | 72% | 2.9 | 8.35 | 0.46 | 1.84 | 79.4% | 4.8% | 15.9% | 50.0% | 5.6% | 27.8% | 16.7% |
| 2025 | 4,000 | 77% | 2.9 | 8.93 | 0.46 | 1.84 | 79.4% | 4.8% | 15.9% | 50.0% | 5.6% | 27.8% | 16.7% |
| 2030 | 4,000 | 80% | 2.9 | 9.28 | 0.46 | 1.84 | 79.4% | 4.8% | 15.9% | 50.0% | 5.6% | 27.8% | 16.7% |
| 2035 | 4,000 | 80% | 2.9 | 9.28 | 0.46 | 1.84 | 79.4% | 4.8% | 15.9% | 50.0% | 5.6% | 27.8% | 16.7% |

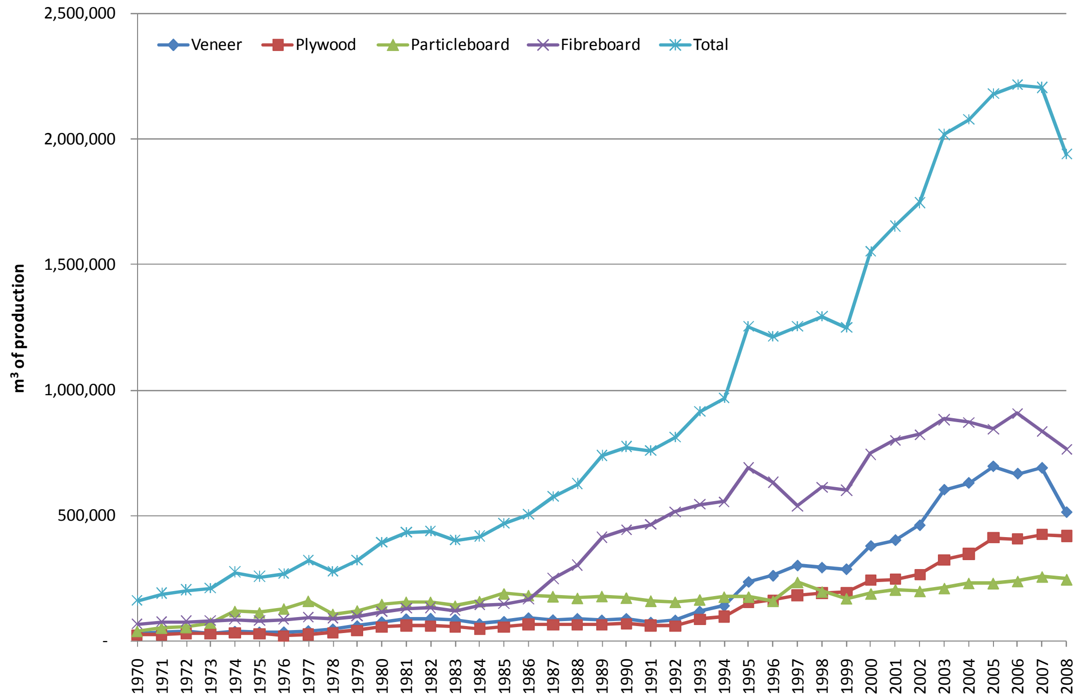
## 9.5. Panels

Panel products consist of:

- Veneer;
- Plywood, including laminated veneer lumber (LVL);
- Fibreboard, including hardboard, softboard and medium density fibreboard (MDF); and
- Particleboard.

Production levels for panel products have been falling recently (Figure 39) and are expected to continue to fall with reduced demand from the construction industry.

**Figure 39** Production of Panel Products




Future levels of production are highly uncertain. We have assumed a fixed annual demand going forward of 2 million $m^3$ of production.

Energy demand is estimated from 2002 intensities. Total primary energy demand in 2002 was estimated at 11.8PJ (Table 54). The main energy source is biomass, with electricity the next most significant input.

**Table 54** Energy Use for Panel Products (PJ)

| Energy Source | 1995 | 1997 | 2002 | 2002 (%) |
|---|---|---|---|---|
| Biomass | 0.97 | 2.12 | 7.6 | 64% |
| Electricity | 0.44 | 0.54 | 2.3 | 19% |
| Fuel Oil | 0.03 | 0.03 | 0.1 | 1% |
| Coal | | | 0.4 | 3% |
| Natural gas | 0.23 | 0.7 | 1.4 | 12% |
| **Total** | 1.67 | 3.39 | 11.8 | 100% |

For modelling purposes, we use an aggregate energy intensity for the sector as a whole. For 1.7m$^3$ of production in 2002, energy demand was 11.8PJ, an energy intensity of 6.76GJ/m$^3$.

**Table 55** Annual energy use projection (PJ) - panels

| Biomass | Electricity | Gas | Total |
|---|---|---|---|
| 10.0 | 2.2 | 1.4 | 13.5 |

## 9.6. Total Energy Demand

Total energy demand is shown in Table 56.

**Table 56** Total Primary Energy Demand by Sub-sector and fuel (PJ)

| Year | Pulp & Paper | Saw-milling | Panels | Coal | Gas | Diesel | Geo-thermal | LPG | Biomass | Elec-tricity | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2008 | 81.2 | 8.8 | 13.6 | 1.4 | 6.3 | 0.5 | 49.0 | 0.3 | 36.4 | 9.6 | 103.6 |
| 2009 | 81.2 | 8.9 | 13.6 | 1.4 | 6.3 | 0.5 | 49.0 | 0.3 | 36.5 | 9.6 | 103.7 |
| 2010 | 81.2 | 9.0 | 13.6 | 1.4 | 6.3 | 0.5 | 49.0 | 0.3 | 36.6 | 9.6 | 103.8 |
| 2015 | 81.2 | 9.6 | 13.6 | 1.5 | 6.4 | 0.5 | 49.0 | 0.3 | 37.1 | 9.6 | 104.4 |
| 2020 | 81.2 | 10.2 | 13.6 | 1.5 | 6.5 | 0.5 | 49.0 | 0.3 | 37.5 | 9.6 | 105.0 |
| 2025 | 81.2 | 10.8 | 13.6 | 1.5 | 6.6 | 0.5 | 49.0 | 0.3 | 38.0 | 9.6 | 105.6 |
| 2030 | 81.2 | 11.1 | 13.6 | 1.5 | 6.7 | 0.5 | 49.0 | 0.3 | 38.3 | 9.6 | 105.9 |
| 2035 | 81.2 | 11.1 | 13.6 | 1.5 | 6.7 | 0.5 | 49.0 | 0.3 | 38.3 | 9.6 | 105.9 |

## 9.7. Greenhouse Gas Emissions

We estimate greenhouse gas emission using the following emission factors (Table 57). We use a zero emission factor for biomass fuel.

**Table 57** $CO_2$ Emissions Factors

| Coal | Gas | Diesel | Geothermal | LPG |
|---|---|---|---|---|
| 88.8 | 52.6 | 69.5 | 3 | 60.4 |

The resulting emissions are shown in Table 58. Despite the large use of energy, much has zero (biomass) or low (geothermal) greenhouse gas emissions.

**Table 58** Estimated Direct $CO_2$ Emissions from Timber Processing ('000 tonnes)

| | Sawmilling | Pulp & Paper | Panels | Total |
|---|---|---|---|---|
| 2008 | 115.1 | 470.9 | 73.6 | 659.6 |
| 2009 | 128.5 | 470.9 | 73.6 | 673.0 |
| 2010 | 117.6 | 470.9 | 73.6 | 662.1 |
| 2015 | 124.9 | 470.9 | 73.6 | 669.4 |
| 2020 | 132.2 | 470.9 | 73.6 | 676.7 |
| 2025 | 139.5 | 470.9 | 73.6 | 684.0 |
| 2030 | 143.9 | 470.9 | 73.6 | 688.4 |
| 2035 | 143.9 | 470.9 | 73.6 | 688.4 |

Impacts of emissions pricing may be low. Using emission prices of $25 and $50/tonne, total emission costs from direct emissions would be approximately $17 million and $33 million respectively; even the highest value is less than 1% of the total export value (Table 47).