INFOMETRICS

The Potential Contribution of Wind Generation to the Economy

report to

New Zealand Wind Energy Association

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CONTENTS

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ABSTRACT

If wind power supplies 20% of electricity generation by 2030 the benefit in terms of real national disposable income per person ranges from $60 to $390, per annum. To put this in perspective, the current average electricity cost per person is about $400 per year.

The introduction of New Zealand's Emissions Trading Scheme (ETS) has tipped the cost structure of electricity generation against thermal generation. While gas is placed in a more favourable position than coal, the main effect of the carbon price is to enhance the competitive position of renewables-based generation, particularly those types that were already competitive at the margin, such as geothermal and wind.

In this paper we use a general equilibrium model of the New Zealand economy to estimate the potential contribution that wind generation could make to national economic welfare by 2030, were it to supply 20% of electricity generation.

Based on a careful assessment of the long run marginal cost of wind power prepared by Deloitte, we find that there is an increase in aggregate economic welfare for various assumptions about the price of carbon, the price of gas and the take-up of plug-in electric vehicles.

1. APPROACH

Wind Power Industry

We estimate the potential contribution that wind generation could make to national economic welfare by 2030, were it to supply 20% of electricity generation. The estimation is based on:

- Application of a multi-industry general equilibrium model of the New Zealand economy – refer Appendix A for details.
- An assessment of long run marginal cost (LRMC) and the structure of LRMC for wind generation, undertaken by Deloitte.[1] This information is incorporated into the general equilibrium model through the addition of a new industry for wind power. All of the output of this industry is sold to the electricity generation industry.

Business as Usual Scenario

All scenarios that look at more wind generation are compared to a 'Business as Usual' (BAU) scenario. The BAU is not intended to be a forecast of the economy. Rather it is intended as a plausible projection of the economy in 2030 in the absence of major external events and major policy changes.

The electricity generation mix in the BAU aligns closely with the MED's *Energy Outlook* Reference Scenario. As in that scenario the carbon price is assumed to be \$50/CO_2e under the New Zealand Emissions Trading Scheme.

Table 1: Electricity Generation 2030

Electricity generation	(PJ)
Coal	0.8
Gas	31.0
Renewables	155.3
Of which Wind	15.4
Total	187.1

Further, it is assumed that even though there is no post-Kyoto international agreement (yet), New Zealand takes on a 2030 obligation of responsibility for any emissions that exceed 85% of 1990 emissions. That is, if domestic policies, notably the ETS does not reduce emissions to 15% below what they were in 1990, New Zealand will have to purchase international emission permits to cover the excess.

More information on the BAU scenario is given in Appendix B.

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[1] Deloitte (2011): *Economics of Wind Development in New Zealand*, report prepared for New Zealand Wind Energy Association.

Between the BAU scenario and the wind power scenarios a number of restrictions need to be imposed on the model. These are known as macroeconomic closure rules. Following NZIER and Infometrics (2009)[2] we assume the following:

1. Labour market closure: Total employment is held constant at the BAU level, with wage rates being the endogenous equilibrating mechanism. Instead of fixed employment, wage rates could be fixed at BAU levels. This implies, however, that the long run level of total employment is driven more by events in the electricity industry than by the forces of labour supply and demand, which we consider unlikely.

2. Capital market closure: In the context of international capital mobility we assume that post-tax rates of return on capital held constant at BAU levels, with capital formation being endogenous.

3. External closure: The balance of payments is a fixed proportion of nominal GDP, with the real exchange rate being endogenous. This means that the cost of any adverse external shock such as having to buy emissions permits on the international market is not met simply by borrowing more from offshore, which is not sustainable in the long term.

4. Fiscal closure: The fiscal position is held constant at the BAU level, with personal income tax rates being endogenous. This prevents the results from being confounded by issues around the optimal size of government.

[2] NZIER and Infometrics (2009): *Macroeconomic impacts of climate change policy: Impact of Assigned Amount Units and International Trading.* Report to Ministry for the Environment.

2. MODELLING RESULTS

We consider four wind power scenarios specified as follows:

Scenario 1: Increase wind generation to be approximately 20% of total generation (compared to 8% in the BAU), with commensurate reductions in thermal generation.

Scenario 2: As in Scenario 1 against a background of CO_2e at $100/tonne instead of $50/tonne.

Scenario 3: As in Scenario 1 against a background of gas priced at $17/GJ instead of $10/GJ (in real 2005/06 prices).

Scenario 4: As in Scenario 1 with additional wind generation to supply 800,000 plug-in electric vehicles.

Table 2 summarises the results.

Scenario 1

The increase in RGNDI of 0.1% represents $60 per person per annum (in 2005/06) prices. Even though the relatively high cost of wind generation causes a small reduction in GDP compared to thermal (particularly CCG) generation, the reduction in emissions means that fewer emission permits need to be purchased from offshore. Thus more of our GDP is available as income to New Zealanders – RGNDI. The effect is strong enough to easily offset the reduction in GDP.

While $60 per person may not seem like much, the macroeconomic closure rules mean that we are not comparing a larger wind generation industry with resources lying idle. Every dollar of capital equipment or person employed in wind generation would otherwise be employed in some other industry – in this case primarily in thermal generation, but at the margin in potentially any industry. Thus a macroeconomic welfare gain from increasing the share of wind in electricity generation is certainly not guaranteed, and moreover will occur only if labour and capital are more productive in wind generation than in other industries and/or if some other externality is alleviated.

In the case of wind generation labour and capital are not more productive at the margin than in other industries (albeit only just), but the effect of the price on greenhouse gas emissions and the advantage that wind generation has over thermal generation in this regard, is strong enough to outweigh the small productivity penalty.

The slightly higher cost of wind generation raises the average price of electricity, causing a reduction in demand of about 2% relative to BAU by 2030. Implicitly this reduction is manifested in less generation from renewables other than wind – hydro and geothermal for instance. This is because by design in Scenario 1, the increase in wind generation is set to equal the reduction in thermal generation. Thus non-wind renewable generation bears the adjustment to lower demand, and some of this costs less than wind. A different specification could be examined, although a significant difference in results is unlikely.

Scenario 2

The percentage changes for Scenarios 1 and 2 are expressed with respect to different bases, with Scenario 1 being expressed relative to a BAU with a carbon price of $50/tonne CO_2e while Scenario 2 is expressed relative to a BAU with a carbon price of $100/tonne. If Scenario 2 was compared against the $50/tonne BAU the results would confound the effect of more wind generation and the effect of a higher carbon price. That is, we are interested in knowing how the macroeconomic effects of more wind generation vary with respect to the carbon price, not in knowing the effect of simultaneously changing the carbon price and the amount of wind generation.

At a carbon price of $100/tonne the economic gain from raising wind's contribution to electricity generation to 20% is 50% higher than when the carbon price is $50/tonne.

There are two forces that generate this benefit. Firstly the avoidance of the now higher priced foreign emission permits means that more of our national income is available to New Zealanders for every tonne of emissions that can be abated domestically. Secondly, the relative efficiency of earning foreign exchange (exporting) to pay for the emission permits is now less attractive compared to using wind generation to reduce emissions. This latter effect is evident in the change in GDP which has switched from a small negative in Scenario 1 to a small positive in Scenario 2.

There is still a reduction in total electricity demand because wind generation is not cheaper than all other generation. However, this reduction is less than before as the higher carbon charge has narrowed, if not reversed the cost difference with respect to fossil fuels.

Note that while the -1.8% change in electricity demand represents the pure effect of more wind generation when the carbon price is $100/tonne, the actual level of generation in Scenario 2 of 178.8 PJ compared to the $183.1 PJ in Scenario 1 is the combined result of both more wind generation and the higher carbon price.

From the data in Table 1 we can work backwards and calculate that under the BAU with the $50 carbon price, total electricity demand is 187.1 PJ, while under the BAU with the $100 carbon price it is 182.0 PJ. Hence the pure effect of the change in the carbon price is -5.1 PJ; a reduction in demand of 2.7%.

Summarising the two scenarios, at a carbon price of $50/tonne, raising wind's contribution to 20% of total electricity generation delivers an increase in RGNDI per person of $60, with this figure rising to $90 at a carbon price of $100/tonne – see Figure 1. To put this in perspective, the current average electricity cost per person is about $400 per year (10.4 GJ per capita at $39/GJ).

Scenario 3

As before the percentage changes for Scenarios 1 and 3 are expressed with respect to different bases, with Scenario 1 being expressed relative to a BAU with a gas price of $10/GJ (in real 2005/06 prices) while Scenario 3 is expressed relative to a BAU with a gas price of $17/GJ. In both scenarios the price of carbon is $50/tonne.

If Scenario 3 was compared against the $10/GJ BAU the results would confound the effect of more wind generation and the effect of a higher gas price. That is, we are interested in knowing how the macroeconomic effects of more wind generation vary with respect to the price of gas, not in knowing the effect of simultaneously changing the price of gas and the amount of wind generation.

The results show quite a dramatic increase on those in Scenario 1 with the lift in RGNDI rising from 0.1% to 0.8%, bringing the change in RGNDI per person to $390.

The change in GDP is now clearly positive at 0.6%. This increase in efficiency is also reflected in electricity demand which increases by 2.7%. At a gas price of $17/GJ wind power has a clear edge so that being able switch from high priced gas to cheaper wind power lowers average electricity prices and boosts demand.

As with regard to Scenario 2 it is worth noting that while the 2.7% change in electricity demand represents the pure effect of more wind generation when the gas price is $17/GJ, the actual level of generation in Scenario 3 of 179.2 PJ compared to the $183.1 PJ in Scenario 1 is the combined result of both more wind generation and the higher gas price.

Working backwards, under the BAU with the $10 gas price, total electricity demand is 187.1 PJ, while under the BAU with the $17 gas price it is 174.5 PJ. Hence the pure effect of the change in the gas price is -12.6 PJ; a reduction in demand of 6.7%. Gas generation falls by about a third.

Interpolating between the Scenario 1 and 3 results with respect to changes in electricity demand, we can infer that the change in demand would be zero if the gas price was about $13/GJ. We can interpret this as a kind of cut-off price – the gas price at which raising wind’s share of electricity generation to 20% has no effect on the overall demand for electricity (in the context of a carbon price of $50/tonne).

However, a note of caution is merited. The cut-off price is also affected by other variables such as changes in the thermal efficiency of gas generation over the next 20 years, substitutability with coal if carbon capture and storage is viable at high carbon prices and changes in the climate which could affect the economics of wind generation. Thus the $13/GJ is not a value about which one should be too definitive.

What we can state more definitively is that under plausible assumptions about the price of gas, the price of carbon and the cost of wind power, raising wind’s share of electricity generation to 20% by 2030 will produce an increase in aggregate economic welfare – as measured by RGNDI. Under the assumptions considered the increase in RGNDI per capita ranges from $60 to $390 per annum by 2030.

Scenario 4

We return to Scenario 1 and add another 2000 GWh of wind energy to cover the requirements of an assumed significant penetration of plug-in electric vehicles into the light vehicle fleet. The parameters for the scenario are drawn largely from CAENZ (2010).[3]

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[3] CAENZ (2010): *Electric Vehicles: Impacts on New Zealand’s Electricity System*, Technical Report, December.

For modelling purposes there are only four key assumptions:

1. The relative efficiency of electricity versus petrol/diesel in terms of energy required per kilometre of travel.
2. The total number of kilometres travelled using vehicles powered by petrol/diesel, that are replaced by electric vehicles.
3. The difference in capital and maintenance costs between electric and internal combustion engine vehicles.
4. The relative wholesale prices of electricity and petrol/diesel.

Fuel efficiency

CAENZ estimate that by 2030 electric vehicles will travel 5.7 km/kWh, or 1.58 km/MJ. This is based on an initial figure of 7 km/kWh which is then adjusted for driving patterns and other demands on the battery such as vehicle air conditioning.

In terms of actual electricity generation, CAENZ add another 10% to account for an assumed 90% battery charging efficiency.

For petrol and diesel vehicles it is necessary to make some projections of the rate of increase in fuel efficiency between now and 2030, and the rate at which new vehicles enter the vehicle fleet.

New light petrol and diesel cars have efficiency factors of about 9.5 l/100km and 7.0 l/100km respectively. On the basis of CAENZ projections we estimate that the average fuel efficiency of vehicles that would be displaced by electric vehicles in 2030 would be about 7.7 l/100km. That translates to about 13 km/l or about 0.4 km/MJ.

Thus for this scenario we assume that electric vehicles are about four times more efficient than petrol/diesel vehicles.

Electric vehicle penetration

CAENZ propose a number of scenarios for the possible penetration of electric cars into the light vehicle fleet, ranging from under one million to more than two million by 2040. We assume 800,000 by 2030 which is within the CAENZ range for 2030 of 250,000 to 1.25 million.

CAENZ also make some assumptions about the number of kilometres that each vehicle travels (and that this does not depend on type of fuel). Depending on the mix of private and commercial vehicles (the latter having higher average annual travel), and what one assumes about changes in demand between 2010 and 2030, the overall average would seem to be about 13,000 km/year.

The combined effect of the above is that about 10,400 million km of travel switches from being powered by fossil fuel to be being powered by electricity.

Clearly though, this number is consistent with all manner of combinations of average annual travel per vehicle and the degree of penetration of electric vehicles.

Combining the numbers for fuel efficiency and electric vehicle penetration implies an annual reduction in oil use of 26 PJ, and an increase in electricity demand of 6.5 PJ. Allowing for the 90% battery charging efficiency raises the electricity requirement to 7.2 PJ, or 2000 GWh.

Vehicle costs

CAENZ propose that by 2030 the capital costs of electric vehicles and petrol/diesel vehicles, for given vehicle features, will have converged. With regard to maintenance, fewer moving parts in electric vehicles should lead to less maintenance, but there is a question around battery lifetimes. These issues are likely to be of second order so for modelling purposes we assume no difference in costs between electric vehicles and petrol/diesel vehicles.

Energy costs

As we are interested in the potential of wind power to support electric vehicles, we use the Deloitte estimate of the LRMC of wind power of $93/MWh, or about $26/GJ used in the previous scenarios.

At the assumed oil price in 2030 of US$150/bbl, the implied wholesale price of petrol (before taxes) is $1.52/l, or $46/GJ. However, a carbon price of $50/tonne adds another 8%. In broad terms then the fuel cost per kilometre of travel for electric vehicles is about 1/8 of that for petrol vehicles.

CAENZ consider a number of scenarios about when electric vehicles would be recharged, with different implications for how much additional generating capacity would be needed. Their general conclusion is that a pro rata increase in generation capacity would not be required if vehicles were mostly charged during off-peak times, centred on 4:00 am. However, as we do not wish to confound our focus on the potential of wind power to meet the electricity demand with changes in the efficiency of the entire electricity system, we assume that wind capacity rises proportionally with wind power output. Thus the modelling results may under-state the benefits from electric vehicles powered (indirectly) by wind.

The results (in Table 2) show an almost tripling of the gain in RGNDI compared to Scenario 1, with the per capita gain increasing from $60 to $170 per annum. As in Scenario 1 there is a small reduction in GDP, but this is more than offset by the saving in the cost of offshore emission permits.

The expected increase in electricity output is evident, but at 6.1 PJ it is about 15% less than the specified 7.2 PJ that is required to supply electric vehicles. This occurs because of our assumption that there is no demand management, implying that generation capacity has to increase proportionally with output. The consequential increase in the average price of electricity causes an across the board reduction in demand. Arguably demand management such as smart meters or some form of ripple control could soften the lift the prices.

There is also a small shift in the composition of generation. Of the 6.1 PJ total lift in electricity output, 7.2 PJ comes from wind generation (as specified), 0.3 PJ comes from more gas generation, and there is a reduction in non-wind renewables generation of by 1.4 PJ.

The scenarios are approximately linear so, for example, Scenario 4 combined with a $100 carbon price (Scenario 2) would lift RGNDI per person by about $260. Similarly, with gas at $17/PJ and electric vehicles, 20% wind generated electricity delivers over $500 per person per annum.

Figure 1
Benefit per person per annum from 20% electricity generated by wind

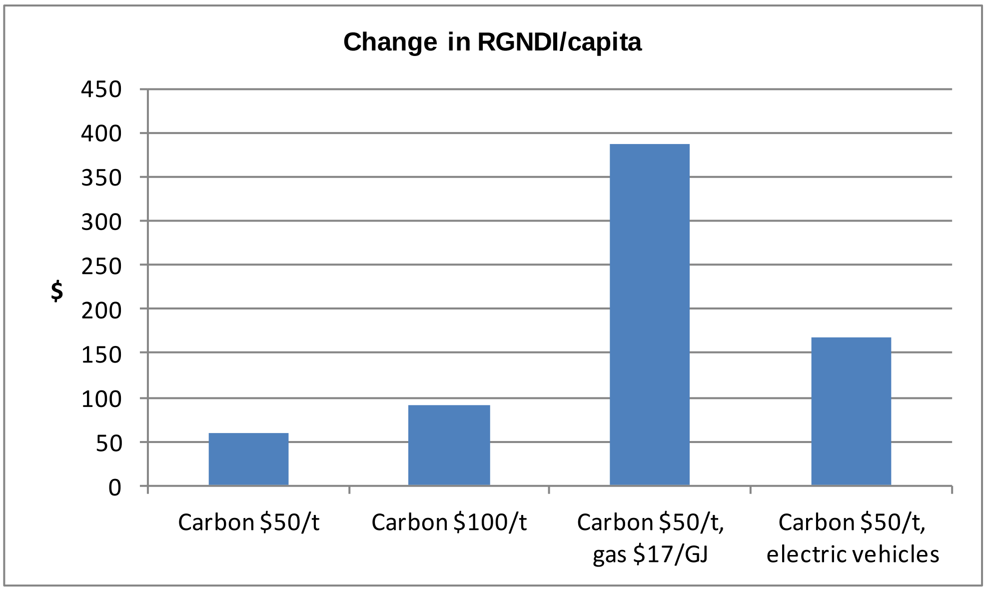

Table 2: Summary of Model Results

	Scenario 1 ↑ wind generation		Scenario 2 CO_2=$100/tonne		Scenario 3 ↑ gas price		Scenario 4 Electric vehicles	
	Level	% Δ on BAU	Level	% Δ on BAU	Level	% Δ on BAU	Level	% Δ on BAU
Private Consumption		0.15[4]		0.23		1.02		0.45
Exports		--0.21		-0.24		0.00		-0.54
Imports		0.23		0.32		0.51		0.72
GDP		-0.02		0.01		0.62		-0.04
RGNDI[5]		0.12		0.18		0.78		0.33
$/capita change in RGNDI	$60		$90		$390		$170	
CO_2e Emissions		-2.7		-2.5		-2.3		-5.0
Electricity generation	(PJ)		(PJ)		(PJ)		(PJ)	
Coal	0.1	-87.5	0.1	-88.3	0.1	-88.9	0.1	-87.5
Gas	11.1	-64.2	9.9	-64.3	2.2	-89.5	11.4	-63.2
Renewables	171.9	10.7	168.8	9.8	176.9	15.5	177.7	14.1
Of which Wind	36.0	133.8	35.7	131.8	34.6	135.4	43.2	180.5
Total	183.1	-2.1	178.8	-1.8	179.2	2.7	189.2	1.1
Wind in total electricity	19.7%		20.0%		19.3%		22.8%	

[4] Results are shown to two decimal places, but this degree of accuracy is probably spurious.

[5] Real Gross National Disposable Income, equivalent to GDP with adjustment for changes in the terms of trade and net remittances overseas.

APPENDIX A: THE ESSAM MODEL

The ESSAM (Energy Substitution, Social Accounting Matrix) model is a general equilibrium model of the New Zealand economy. It takes into account the main inter-dependencies in the economy, such as flows of goods from one industry to another, plus the passing on of higher costs in one industry into prices and thence the costs of other industries.

The ESSAM model has previously been used to analyse the economy-wide and industry specific effects of a wide range of issues. For example:

- Energy pricing scenarios
- Changes in import tariffs
- Faster technological progress
- Policies to reduce carbon dioxide emissions
- Funding regimes for roading
- Release of genetically modified organisms

Some of the model's features are:

- 53 industry groups, as detailed in the table below.
- Substitution between inputs into production - labour, capital, materials, energy.
- for energy types: coal, oil, gas and electricity, between which substitution is also allowed.
- Substitution between goods and services used by households.
- Social accounting matrix (SAM) for complete tracking of financial flows between households, government, business and the rest of the world.

The model's output is extremely comprehensive, covering the standard collection of macroeconomic and industry variables:

- GDP, private consumption, exports and imports, employment, etc.
- Demand for goods and services by industry, government, households and the rest of the world.
- Industry data on output, employment, exports etc.
- Import-domestic shares.
- Fiscal effects.

Production Functions

These equations determine how much output can be produced with given amounts of inputs. A two-level standard translog specification is used which distinguishes four factors of production – capital, labour, and materials and energy (KLEM), with energy split into coal, oil, natural gas and electricity (CONE).

Intermediate Demand

A composite commodity is defined as one which has imperfectly substitutable domestic and imported components - where relevant. The share of each of these components is determined by the elasticity of substitution between them and by relative prices.

Price Determination

The price of industry output is determined by the cost of factor inputs (labour and capital), domestic and imported intermediate inputs, and tax payments (including tariffs). World prices are not affected by New Zealand purchases or sales abroad.

Consumption Expenditure

This is divided into Government Consumption and Private Consumption. For the latter eight household commodity categories are identified, and spending on these is modelled using price and income elasticities in an AIDS framework. An industry by commodity conversion matrix translates the demand for commodities into industry output requirements and also allows import-domestic substitution.

Government Consumption is usually either a fixed proportion of GDP or is set exogenously. Where the budget balance is exogenous, either income tax rates or transfer payments are assumed to be endogenous.

Stocks

Owing to a lack of information on stock change, this is exogenously set as a proportion of GDP, domestic absorption or some similar macroeconomic aggregate. The industry composition of stock change is set at the base year mix, although variation is permitted in the import-domestic composition.

Investment

Industry investment is related to the rate of capital accumulation over the model's projection period as revealed by demand for capital in the horizon year. Allowance is made for depreciation. Rental rates or the service price of capital (analogous to wage rates for labour) also affect capital formation. Investment by industry of demand is converted into investment by industry of supply using a capital input-output table. Again, import-domestic substitution is possible between sources of supply.

Exports

These are determined from overseas export demand functions in relation to world prices and domestic prices inclusive of possible export subsidies, adjusted by the exchange rate. It is also possible to set export quantities exogenously.

Supply-Demand Identities

Supply-demand balances are required to clear all product markets. Domestic output must equate to the demand stemming from consumption, investment, stocks, exports and intermediate requirements.

Balance of Payments

The balance of payments is defined as receipts from exports plus net factor receipts, less payments for imports; each item being measured in domestic currency net of subsidies or tariffs.

Factor Market Balance

In cases where total employment of a factor is exogenous, factor price relativities (for wages and rental rates) are usually fixed so that all factor prices adjust equi-proportionally to achieve the set target.

Income-Expenditure Identity

Total expenditure on domestically consumed final demand must be equal to the income generated by labour, capital, taxation, tariffs, and net capital inflows. Similarly, income and expenditure flows must balance between the five sectors identified in the model – business, household, government, foreign and capital.

Industry Classification

The 53 industries identified in the ESSAM model are defined below. Industries definitions are according to Australian and New Zealand Standard Industrial Classification (ANZSIC).

1	HFRG	Horticulture and fruit growing
2	SBLC	Livestock and cropping farming
3	DAIF	Dairy and cattle farming
4	OTHF	Other farming
5	SAHF	Services to agriculture, hunting and trapping
6	FOLO	Forestry and logging
7	FISH	Fishing
8	COAL	Coal mining
9	OIGA	Oil and gas extraction, production & distribution
10	OMIN	Other Mining and quarrying
11	MEAT	Meat manufacturing
12	DAIR	Dairy manufacturing
13	OFOD	Other food manufacturing
14	BEVT	Beverage, malt and tobacco manufacturing
15	TCFL	Textiles and apparel manufacturing
16	WOOD	Wood product manufacturing
17	PAPR	Paper and paper product manufacturing
18	PPRM	Printing, publishing and recorded media
19	PETR	Petroleum refining, product manufacturing
20	CHEM	Fertiliser and other industrial chemical manufacturing
21	RBPL	Rubber, plastic and other chemical product manufacturing
22	NMMP	Non-metallic mineral product manufacturing
23	BASM	Basic metal manufacturing
24	FABM	Structural, sheet and fabricated metal product manufacturing
25	MAEQ	Machinery and other equipment manufacturing
26	OMFG	Furniture and other manufacturing
27	EGEN	Electricity generation
28	EDIS	Electricity transmission and distribution
29	WATS	Water supply
30	WAST	Sewerage, drainage and waste disposal services
31	CONS	Construction
32	TRDE	Wholesale and retail trade
33	ACCR	Accommodation, restaurants and bars
34	RDFR	Road freight transport
35	RDPS	Road passenger transport
36	RAIL	Rail transport
37	WATR	Water transport
38	AIRS	Air transport and transport services
39	COMM	Communication services
40	FIIN	Finance and insurance
41	REES	Real estate
42	EHOP	Equipment hire and investors in other property
43	OWND	Ownership of owner-occupied dwellings
44	SRCS	Scientific research and computer services
45	OBUS	Other business services
46	GOVC	Central government administration and defence
47	GOVL	Local government administration
48	SCHL	Pre-school, primary and secondary education
49	OEDU	Other education
50	HOSP	Hospitals and nursing homes
51	OHCS	Other health and community services
52	CULT	Cultural and recreational services
53	PERS	Personal and other community services

Appendix B: The BAU Scenario

The projection period is to 2030/31, implying 25 years from the model's 2005/06 base year. The main input assumptions for the model are discussed below.

Population

Population is projected using Statistics New Zealand's (SNZ) Series 5. It is based on a middle path with respect to fertility, mortality and migration; namely medium fertility, medium mortality and net immigration of an average 10,000 people per annum. This yields a projected population in 2030/31 of 5,149,000, implying an average growth rate from the model's 2005/06 base year of 0.8% per annum.

Labour Force

The projected labour force is 2,650,000, again based on SNZ Series 5, with medium (as opposed to low or high) labour force participation rates. Implied growth from 2005/06 is 0.7% pa.

The model requires either total employment or the average wage rate to be set exogenously. Our preferred approach for the BAU is to make an assumption about the rate of unemployment and let the model produce whatever profile of wage rates is consistent with this, rather than the other way around.

In a modern economy the rate of unemployment in the long run is driven primarily by demographic factors and labour market regulations, whereas wage rates are ultimately a function of the growth of the economy. Thus it is more plausible to assume some rate of unemployment that society is prepared to tolerate, which is likely to cover a fairly narrow range, than to assume some set growth path for wages – which could easily produce totally unrealistic projections of unemployment.

We assume a long run structural unemployment rate of 3.5%; on the low side of historical rates, but recognising the projected aging of the population and the associated slow growth in labour force.

Energy and Energy Efficiency

The model requires projections of rates of improvement in energy efficiency, often referred to in energy models as the AEEI; the autonomous energy efficient improvement parameter. This is fuel specific and hence is required for coal, natural gas, oil products and electricity.

Typically in our medium to long term modelling we have used 1% pa for all fuels except for electricity use by households where a lower rate of 0.5% pa has been used. This is not because the efficiency of household appliances is assumed to improve at a slower rate than industrial machinery. Rather it is a crude way to capture the increasing use of electrical appliances (such as computers and television decoders) that were previously less prevalent and that are frequently left on, even if only in stand-by mode, for extended periods of time. To this one might add the increasing use of clothes driers associated with the move to apartment living, and heat pumps which, while very efficient, are often used for air conditioning in homes which had no air conditioning prior to installation of a heat pump.

Oil Price

The oil price is immensely difficult to forecast. We defer to the comprehensive discussion and analysis in NZTA (2008)[6] which shows a number of projections for the price of oil in 2028 ranging between US65/bbl and US$230/bbl, with an average of about US$115/bbl (all in 2008 prices). We assume a price of US$150/bbl for 2030/31.

Balance of Payments

New Zealand has a long record of persistent and pronounced balance of payments deficits. The current economic recession has led to some improvement in the current account, and we expect that in the medium to long term further improvements will occur. With other countries improving their economic management and providing profitable opportunities for investment, New Zealand will find it more difficult to attract foreign investment to cover sizeable balance of payments deficits. However, for 2030/31 we assume a balance of payments deficit of 3.5% of nominal GDP.

[6] New Zealand Transport Agency (2008): *Managing transport challenges when oil prices rise,* Research Report 04/08, Wellington.