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New Zealand Business Roundtable and Petroleum Exploration and Production Association of New Zealand

Carbon Mitigation Scenarios

Introduction

The government's aspirations are for New Zealand to be 'carbon neutral' by 2050, with intermediate carbon neutrality goals for major sectors - electricity (2025), stationary energy (2030), transport (2040), total energy (2040). On a worldwide basis, carbon neutrality means carbon dioxide equivalent (CO_2e) emissions are offset by carbon absorption. For any given country, however, carbon neutrality may also include the purchase of carbon credits from other countries to offset domestic emissions, with neutrality being defined as applying only to emissions above a given benchmark – 1990 emissions under the Kyoto Protocol for the period to 2012...

A goal of achieving carbon neutrality at a date as far out as 2050 is difficult to model meaningfully. Thus in this study we look at 2025 (also the focus of previous work for the Emissions Trading Group) and select a milestone for 2025 that relates to the 1990 benchmark and is consistent with the 2050 objective.

We propose a 2025 target of restoring New Zealand emissions to 1990 levels. (This is a more conservative goal than that proposed by the Intergovernmental Panel on Climate Change (IPCC), and supported by New Zealand at the recent Bali meeting, which was to cut emissions by 25-40% below 1990 levels by 2020.) On this basis New Zealand would not even have made any progress towards carbon neutrality (it would not have achieved reductions such as those proposed by the IPCC relative to the 1990 benchmark) but it would have clawed back the present excess of emissions over 1990 levels (estimated at 25% for 2005, excluding carbon sinks). It is assumed that the combination of policy actions and new technologies after 2025 would enable New Zealand to reach the carbon neutrality goal by 2050.

Another priority goal for the government is to raise the growth rate of the economy to around 4% pa in order to lift per capita incomes into the top half of the OECD range. We assume an economic growth rate of 4.5-5% per annum for a Business as Usual (BAU) scenario, so that with emissions reduced towards 1990 levels the economy can still grow at around 4% per annum and thus meet the government's growth objectives.

In this study sinks are ignored because in the long run forests are carbon neutral.

Scenario Outline

Scenario A High growth Business as Usual scenario to 2025. No carbon price and no international emissions obligations.

Scenario B Emissions Trading Scheme with a domestic carbon price of NZ$300/tonne, but an international carbon price of NZ$100/tonne (which is within the range of current forecasts for deep emission cuts). New Zealand's 'international allowance' is 30 Mt. Aggregate employment and investment are held at BAU levels.

Countries with which we compete internationally, either with respect to exporting or import substitution, do not have significant emissions mitigation policies. (This likely to be the case at least for China and India, and possibly for the United States.)

Factor use and the current account balance are held at Scenario A levels. We are interested in the welfare loss caused by changes in the real exchange rate, changes in allocative efficiency and so on.

Scenario C Scenario B with lower factor use.

Scenario A represents a 'high growth' BAU scenario to 2025. It is based on the BAU scenario used in the analysis of the ETS for the Emissions Trading Group, but with the following differences:

- Approximately 47,000 extra employment, associated with a change in population of 112,000 (from higher immigration) and a slightly higher participation rate.
- Faster growth in the capital stock; 3.5% pa instead of 2.5% pa.
- A doubling of total factor productivity from 1.3% pa to 2.6% pa.

Of course there are other combinations that would deliver faster economic growth, but altering the input mix is unlikely to have a significant effect on how the economy responds to a carbon price.

While we have not looked at the specific policies that would be required to raise economic growth, the rate of growth of government consumption, at 3.1% pa, is unchanged from the original (ETG) BAU. Thus the government constitutes a smaller proportion of the economy in the higher growth BAU – something that we would see as crucial to securing a higher rate of growth.

Scenario B in effect explores the impact of a domestic 'shadow price' of carbon where the international price is supplemented by regulatory and other non-price measures such as banning thermal generation. Ideally, the carbon price needed to achieve 1990 emission levels would be generated by the model. However, given the parameters of the model, the impact of the very high carbon prices that would be required could not be realistically modelled. For that reason the model explores instead how far New Zealand would be away from a 1990 emissions goal even at a carbon price of NZ$300/tonne.

Scenario C is motivated by the recognition that the model assumes full utilisation of all 'given' resources and that resources displaced by policy action to reduce emissions are reallocated to their next most valued use. Thus the model does not handle issues such as investment uncertainty and transitional costs particularly well. These can be important, as economic restructuring in New Zealand in the 1980s demonstrated. In order to gauge their possible effects, Scenario C makes downward adjustments to the assumptions for growth in employment, investment and productivity used in Scenario B.

Results

Macroeconomic Picture

In Scenario A, GDP growth to 2024/25 emerges at 4.6% pa from 2004/05. With growth from 2005 to 2008 likely to be slower than this, the implied growth rate from 2008 to 2025 is closer to 4.9% pa.

Given the increase in total factor productivity and the effect this has on international competitiveness it is not surprising that exports are the fastest-growing component of GDP. By design, investment also increases rapidly – arguably a necessary adjunct to the realisation of higher productivity.

Emissions in the BAU total 179.1 Mt of CO_2e, although removing those associated with international transport (which are exempt under Kyoto) leaves 172.2 Mt. In 1990 emissions were 62.3 Mt and 59.9 Mt respectively. Thus the increase from 1990 to 2025 is over 180%.

For comparative purposes the lower growth BAU to 2025 in the ETG report produced emissions of 111.6 Mt (excluding international transport), an increase of about 85% on 1990 emissions.

Scenario B produces a reduction in emissions of over 30%, but with gross emissions still at 115 Mt, 85 Mt of emission units must be purchased on the world market. At $100/tonne the cost is $8.5 billion. This is obtained by imports falling by more than exports, reflecting a decline in private consumption of 3.1%. Higher costs force exporters to move up the demand curve, although this has the benefit of delivering higher terms of trade.

Gross domestic product falls by less (1.4%), largely because of the assumption of the utilisation of labour and capital being held at BAU levels. Real private consumption or real GDP measured in world prices are better metrics of welfare than the volume of goods and services produced.

Table 1: Macroeconomic Results

		Scenario A	Scenario B	
		BAU % pa on 2005		% ∆ on BAU
Private Consumption		4.8%		-3.1%
Government Consumption		3.1%		0.0%
Investment		5.0%		0.0%
Exports		6.0%		-5.1%
Imports		5.7%		-6.2%
GDP		4.6%		-1.4%
Real exchange rate		--		-1.1%
Terms of trade		--		5.2%
	1990	2025	2025	
Emissions	Mt	Mt	Mt	
CO_2	25.3	84.7	52.6	-37.9%
CH_4 and N_2O	37.0	94.4	65.7	-30.3%
	62.3	179.1	118.3	-33.9%
less International transport	2.4	6.9	3.8	-45.0%
	59.9	172.2	114.6	-33.5%

Energy Prices

Table 2 shows the estimated effects of a carbon price of $300/tonne on energy prices. The estimated price effects may differ from a straightforward calculation of the 'impact effects' as they take into account indirect effects. Generally the indirect effects will be positive because of the impact of higher energy prices on other inputs. For example, oil prices rise by the amount of the carbon charge, plus the increase in the cost of transporting it.

Table 2: Energy Prices (2025)

		Price 2007 (excl GST)	Absolute price rise (on BAU)	Price Scenario B (excl GST)
Electricity*	Household	18.7c/kWh	18c/kWh	36.7c/kWh
	Business	8.2c/kWh		26.2c/kWh
Gas	Household	$22.7/GJ	$16.3/GJ	$39.0/GJ
	Business	$6.4/GJ		$22.7/GJ
Petrol		$1.56/l	89c/l	$2.55/l
Coal	Business	$5/GJ	$30/GJ	$35/GJ

* Using MfE guideline of 600 t CO_2/GWh

As the model does not include the absolute price level, the incremental price effects are measured with respect to current 2007/08 prices. These are approximate – petrol prices are volatile, business prices vary widely between different industries, and some prices are confidential.

Electricity Generation

Table 3 shows the effects of the carbon charge on electricity generation.

Table 3: Electricity Generation*

	Dec yr 1990	Dec yr 2006	Scenario A BAU (PJ)	Scenario B % ∆ on BAU
Coal	2.2	18.4	34.0	-26.2%
Oil	0.0	0.1	1.6	-31.3%
Gas (& cogen)	19.2	33.1	44.2	-26.2%
Renewables	90.1	97.4	241.1	-37.9%
Total	111.5	149.0	320.9	-35.0%

* excludes wood & biogas

While the growth of supply between 2006 and the BAU is concentrated in renewables generation, the imposition of a carbon price leads ironically to a larger fall in renewables generation (relative to BAU) than in thermal generation. This comes about because the overall increase in electricity prices is so large (over 100%) that demand is reduced and some of the more expensive renewable options such as wind are no longer required.[1] We should, however, bear in mind the error margin in projections of the electricity supply curve two decades hence.

Considering the government's quasi-moratorium on new thermal generation, an option for a follow-up scenario might be to scale back thermal generation to 2006 levels, or even to zero.

Industry Output

Table 4 shows the effects of the carbon charge on a group of selected industries.

Table 4: Industry Gross Output

	Scenario B % ∆ on BAU
Sheep farming	-32.4%
Dairy farming	-27.9%
Petroleum	-27.4%
Non-metallic	-9.4%
Basic metals	-31.0%
Road transport (excl households)	-7.6%
Rail & water transport	-2.8%
Water, Air transport etc	-1.8%

Reflecting the fall in emissions in Table 1, output of pastoral farming is around 30% below BAU levels as these industries have almost no opportunity to

[1] See MED's *New Zealand's Energy Outlook to 2030*, p98.

reduce emissions other than by reducing the volume of output.[2] This is probably too extreme an assumption, especially with a domestic carbon price of $300/tonne. A sensitivity test with emission abatement options of the type discussed in a recent paper by Simon Terry could be interesting.

Oil Refining and Basic Metals (steel and aluminium) experience a similar fall in output, but Non-metallic Mineral Products (cement) does not perform as poorly. It is not involved in exporting and, while higher domestic cement prices encourage more importing of cement, local operators have the advantage of location, delivery times and certainty of supply. Nevertheless, it might be worth examining a scenario in which one of the cement plants closes.

Rail, water and air transport gain at the expense of road transport, although even road transport benefits from a shift to public transport. Oil demand by private households (not shown in the table) falls by 16%.[3]

Summary

A $300/tonne domestic carbon prices reduces emissions by about one third relative to BAU. This still leaves emissions over 90% above 1990 levels. With a 30 Mt 'post Kyoto' allowance New Zealand has to buy 85 Mt of emission units on the international market, at an assumed price of $100/tonne. More resources are required for exporting, causing a fall in private consumption of 3.1% relative to BAU. This is about $1,200 per person in 1995/96 prices – about $1,500 in current prices. Per household the effect is $4,000 in current prices.

A number of caveats should be noted:

1. Countries with which we compete internationally, either in exporting or import substitution, do not have significant emissions mitigation policies. Thus the effect of New Zealand's policies on the international competitiveness of New Zealand's industries could be overstated, although even the European Union has foreshadowed possible action to protect industries such as steel, cement and aluminium.

2. As noted, possibilities for reducing emissions in pastoral farming other than by reducing output are extremely limited. A high price of carbon could make this assumption unrealistic.

3. No <u>direct</u> account has been taken of other government policies aimed at reducing emissions. However, we need to be careful here. A domestic carbon price of $300/tonne can be expected to be a proxy for some other policies such as more home insulation, more use of public transport, and changes in the mix of electricity generation.

[2] There is limited substitutability between different types of fertiliser, which affects emissions of nitrous oxide.
[3] A small amount of oil is used for space heating.

Incorporating targeted policies in these areas in addition to a high carbon charge could imply double counting.

The sorts of policies that the model cannot readily proxy with a higher carbon price are complete closure of an industry (such as coal-fired generation) or the introduction of entirely new technologies that are not captured in the model's substitution elasticities. Two examples are carbon sequestration and electric cars.

4. Some industries may not be able to withstand output reductions of 25-30% relative to BAU. Falls of this magnitude may lead to total closure, although one should probably look at the size of such falls relative to current output, not relative to the BAU, to gain a better perspective of the likelihood of closure.

5. Macroeconomic effects of the size that occur in Scenario B could lead to lower inward migration and lower investor confidence. We look at this in the following scenario.

Scenario C

Underlying Scenario A is the proposition that higher economic growth is not only the result of higher employment, more investment and greater productivity, but that higher economic growth itself has positive feedback effects on employment (via immigration), investment (via expectations and business confidence) and productivity (via embodiment in new capital and expansion in R&D).

The 3.1% fall in private consumption in Scenario B is equivalent to a reduction in the growth rate of around 0.2% pa between 2005 and 2025. Thus we might expect to see a somewhat slower rate of immigration, implying a lower labour force. This would reduce economic growth even more, lead to still less immigration and so on in a (convergent) downward spiral. Quantitative measurement of this effect is beyond the scope of this study. One difficulty is which variable defines 'economic growth'. Is it private consumption, GDP, real wages, employment or some combination of these variables? While Scenario B shows a marked change in private consumption, GDP shows a smaller change and employment does not change at all (by assumption). And growth in GDP presumably has a bigger effect on investment and business confidence than does growth in private consumption.

Just how the total level of resource inputs (labour, capital and productivity) might respond to the type of economic picture portrayed in Scenario B is difficult to predict. Indeed this is one reason for adopting the standard macroeconomic closure assumption of total input invariance between scenarios. However, we should be cognisant of the possibility that a severe economic shock might have negative effects on labour, capital and productivity that persist for some time.

As a sensitivity test, therefore, we explore here the effects of combining Scenario B with the previous increases in resource use adopted in Scenario A reduced by about 30%.[4] That is:

- Approximately 33,000 increment to employment, compared to 47,000 in Scenario A and B.

- Growth in the capital stock of 3.2% pa instead of 3.5% pa.

- Total factor productivity at 2.2% pa instead of 2.6% pa.

Tables 5 shows the macroeconomic results. Gross domestic product is over 11% below Scenario B which, over the period 2005-2025 implies a reduction in the growth rate of about 0.6% pa relative to BAU.

Table 5: Macroeconomic Results

	Scenario B		Scenario C	
		% Δ on BAU		% Δ on BAU
Private Consumption		-3.1%		-14.1%
Government Consumption		0.0%		0.0%
Investment		0.0%		-3.3%
Exports		-5.1%		-15.8%
Imports		-6.2%		-12.0%
GDP		-1.4%		-11.2%
Real exchange rate		-1.1%		4.6%
Terms of trade		5.2%		10.8%
Emissions	Mt		Mt	
CO_2	52.6	-37.9%	45.9	-45.8%
CH_4 and N_2O	65.7	-30.3%	58.9	-37.5%
	118.3	-33.9%	104.9	-41.4%
less International transport	3.8	-45.0%	3.3	-51.5%
	114.6	-33.5%	101.5	-41.0%

The greater tightness of the factor markets leads directly to a rise in the real exchange rate, causing exports to fall by more than in Scenario B. So again the entire current account adjustment to the cost of purchasing international emission permits falls on imports, albeit that the adjustment is less than in Scenario B because emissions are less and the terms of trade are higher. The mirror image of the fall in imports is the 14% fall in private consumption.

Another way to interpret this scenario is as a representation of an economy with more rigid factor prices, forcing a greater share of the adjustment to a carbon charge to be borne by changes in the quantity of inputs. Clearly this leads to a worse macroeconomic outcome than an adjustment process that accommodates a fall in the real exchange rate.

[4] This is an approximate estimate of the convergence point of lower input use leading to lower growth, leading to lower inputs and so on.

Industry impacts are summarised in Table 6. All industries exhibit greater falls in output compared to BAU than in Scenario B, though the largest relative differences between Scenarios B and C occur in transport, a direct result of the reduction in domestic activity. Scenario C produces a reduction in emissions of over 40%, but at 101.5 MT gross emissions remain nearly 70% above 1990 levels. Thus under this scenario as well as Scenario B, by 2025 New Zealand would have moved further away from the goal of reducing emissions to 1990 levels rather than towards it. At $100/tonne, the cost of purchasing excess emissions on the world market is $7.15 billion.

As noted above, for some industries large declines in output may be untenable. The 44% decline in output of Base Metals implies a reduction in its rate of growth between 2007/08 and 2024/25 of about 2.2% per annum relative to BAU, but this might well exceed its expected BAU growth.

Table 6: Industry Gross Output

	Scenario C % Δ on BAU
Sheep farming	-40.0%
Dairy farming	-34.0%
Petroleum	-35.5%
Non-metallic	-19.7%
Basic metals	-44.1%
Road transport (excl households)	-20.6%
Rail & water transport	-15.8%
Water, Air transport etc	-15.2%

Summary

In summary, once the effects on aggregate investment, employment and productivity of investment uncertainty and transitional costs are taken into account, policy action to reduce New Zealand's emissions could lead to a fall in private consumption of 14% relative to BAU. This is about $7,000 per person in current prices or $19,000 per household. It also implies a doubling of electricity prices relative to 2007/08 and increases in petrol prices of more than 50% Nevertheless, despite these adverse effects on households, New Zealand's emission levels rise significantly rather than reduce relative to 1990 levels, calling into question the consistency of the government's twin goals of growth and carbon neutrality.

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