New Zealand's EnergyScape™





2000 2005 2030 2050

Supporting material for questionnaire

June 2009

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SUPPORTING MATERIAL FOR QUESTIONNAIRE

Below is a series of graphics which may give the reader some insight into historic and projected developments relevant to New Zealand's energy supply. The material loosely follows the order defined by the questionnaire.

Item 1 - An important parameter that affects future growth expectations is the range in population forecasts.

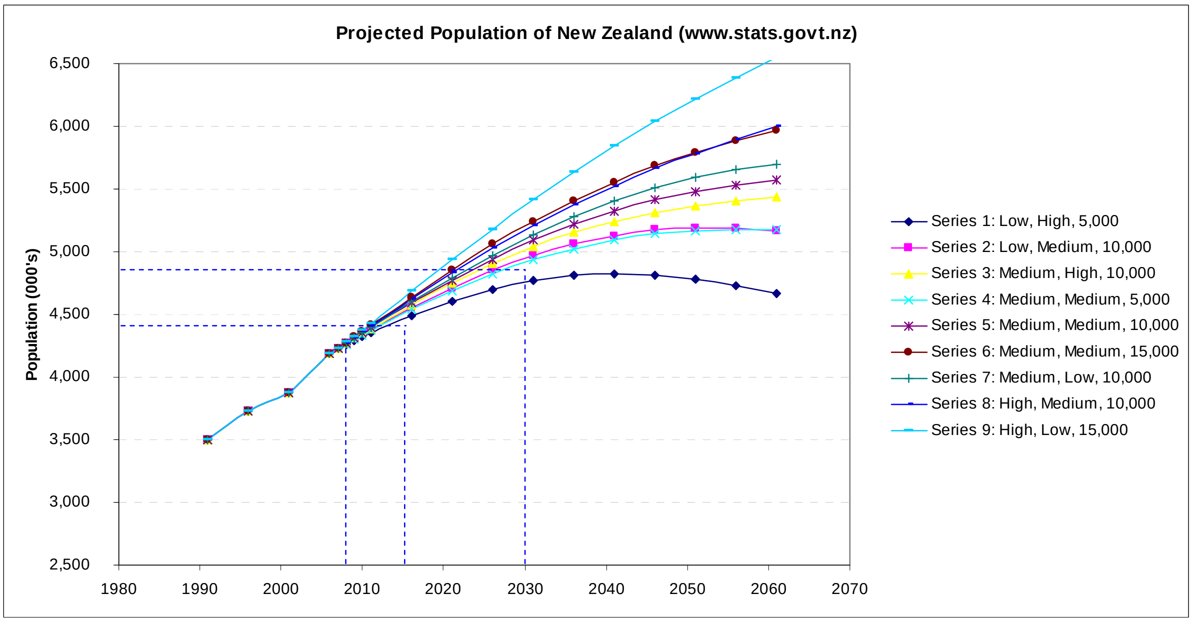

Figure A: New Zealand population forecasts

StatsNZ provides a range of projections, for example Series 5: assumes *medium* fertility, *medium* mortality and long-run annual net migration of *10,000*)

Item 2 – New Zealand's economic prosperity has been steadily declining since the 1970s, much of this is due to declining exports (as % GDP).

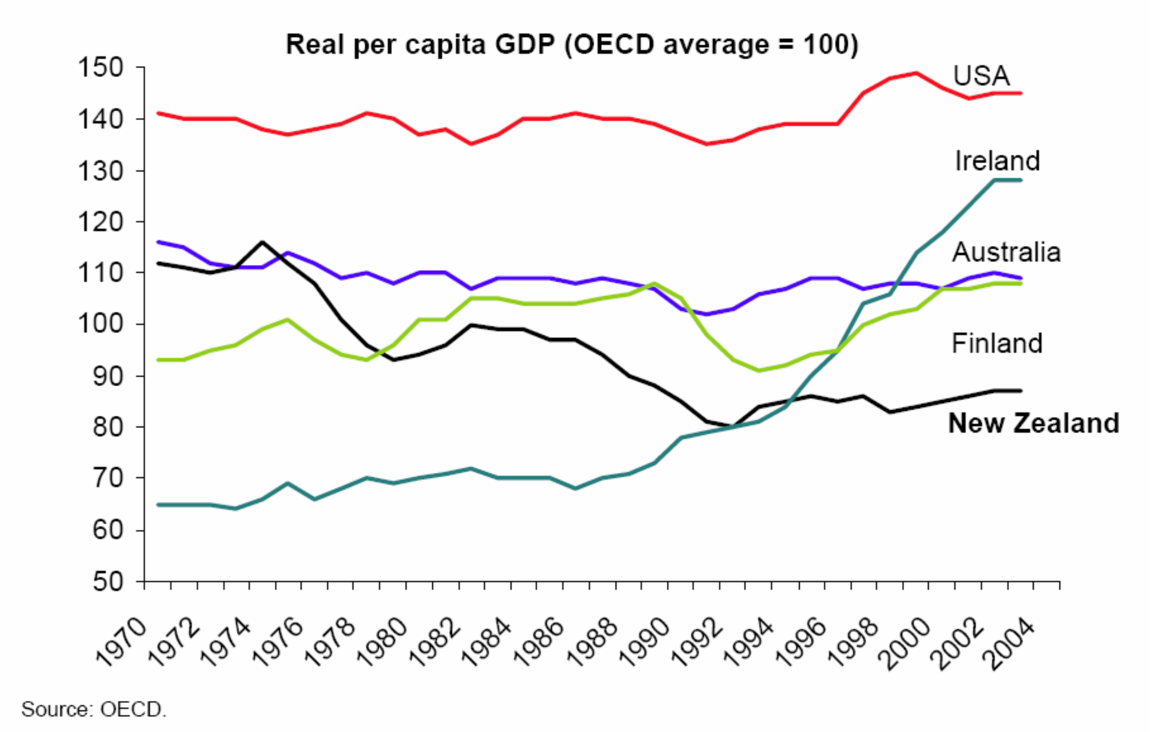

Figure B: GDP trends in select OECD countries

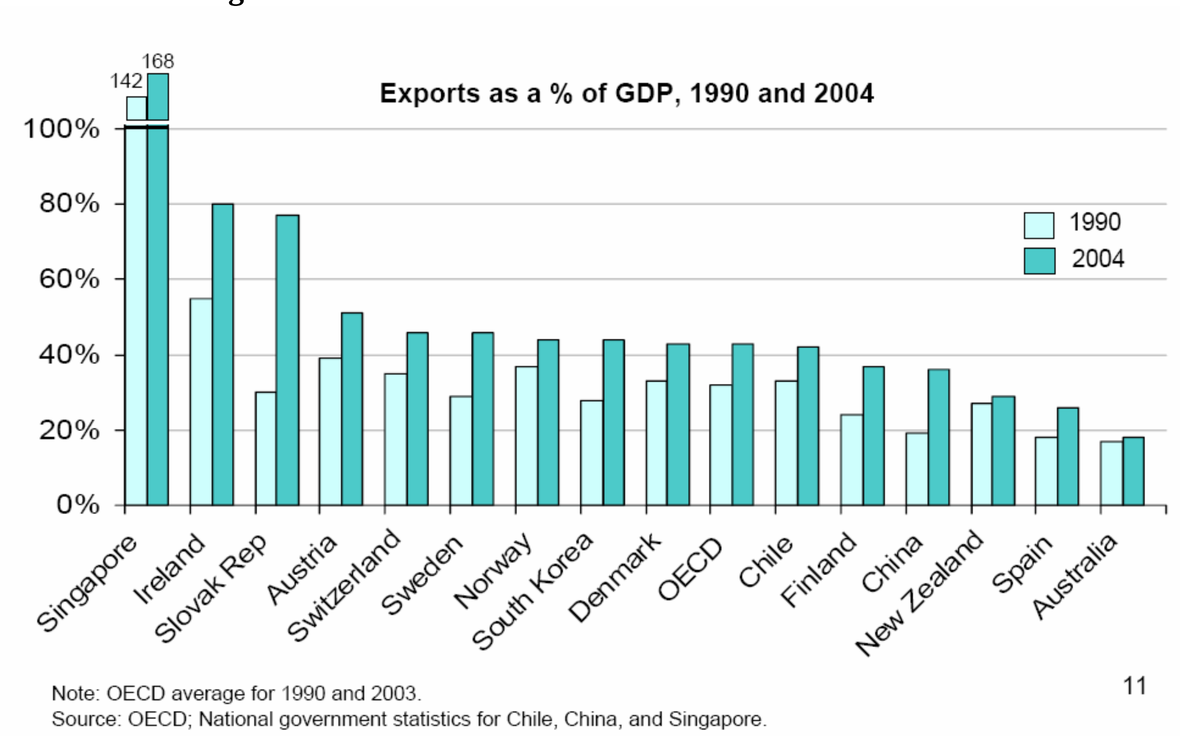

Figure C: Export as %GDP trends in select OECD countries

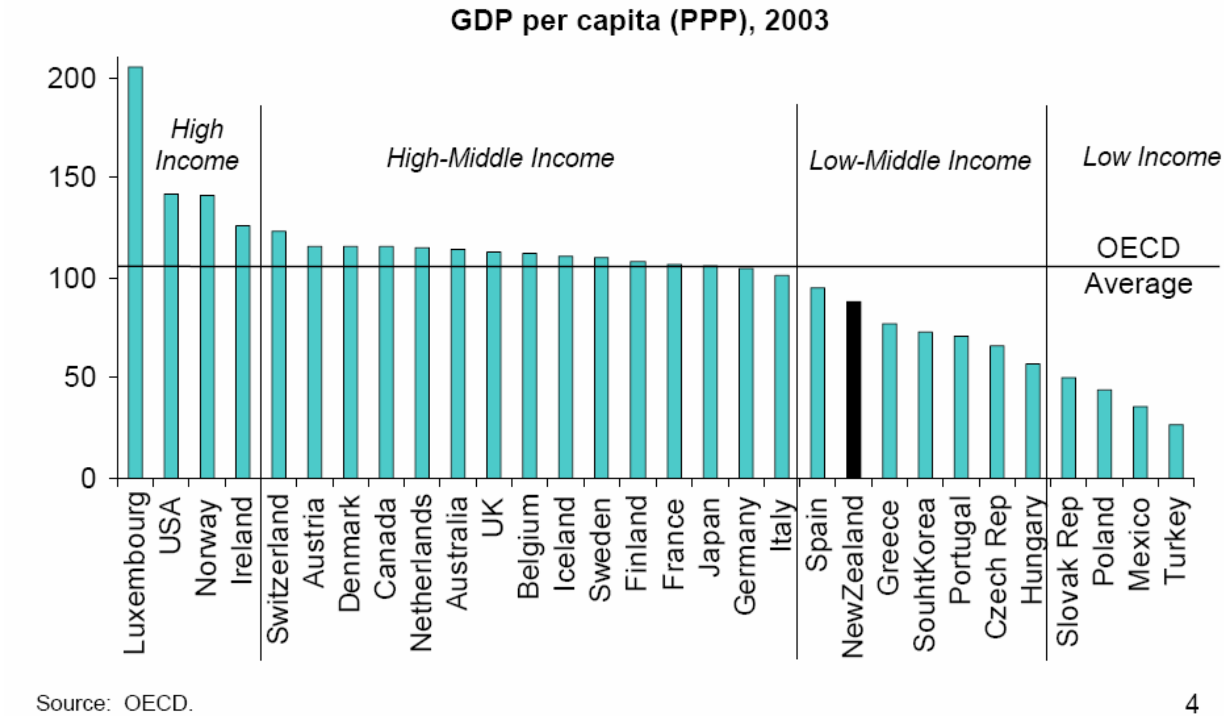

Figure D: GDP per capita in select OECD countries

Source: http://www.nzinstitute.org/Images/uploads/Aucklands_role_in_NZ_productivity_challenge_280206.pdf

Item 3 - There is much speculation that the total world oil production capacity has peaked or will soon peak. This at a time when demand for oil products continues to grow rapidly.

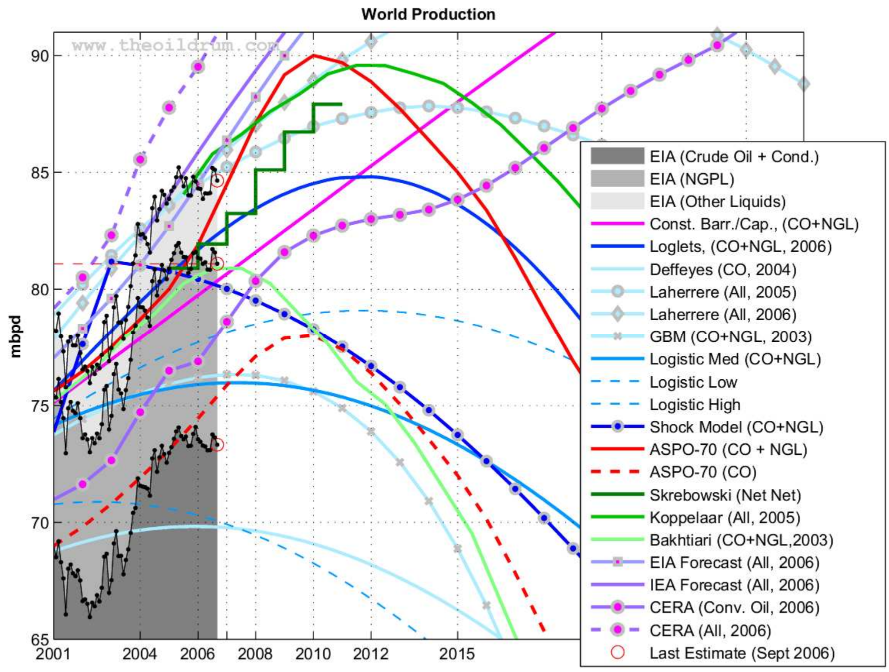

Figure E: An update on the last production numbers from the EIA along with different oil production forecasts. ***World oil production (EIA Monthly) and various forecasts (2001-2027).***

Source: http://www.theoildrum.com/story/2006/11/30/8324/0934 (accessed 23-10-2008)

This graph shows historical and projected oil production volumes from various sources. It indicates that most expect the oil production volumes to decrease, it seems uncertain when this will happen. Some expect no production decrease.

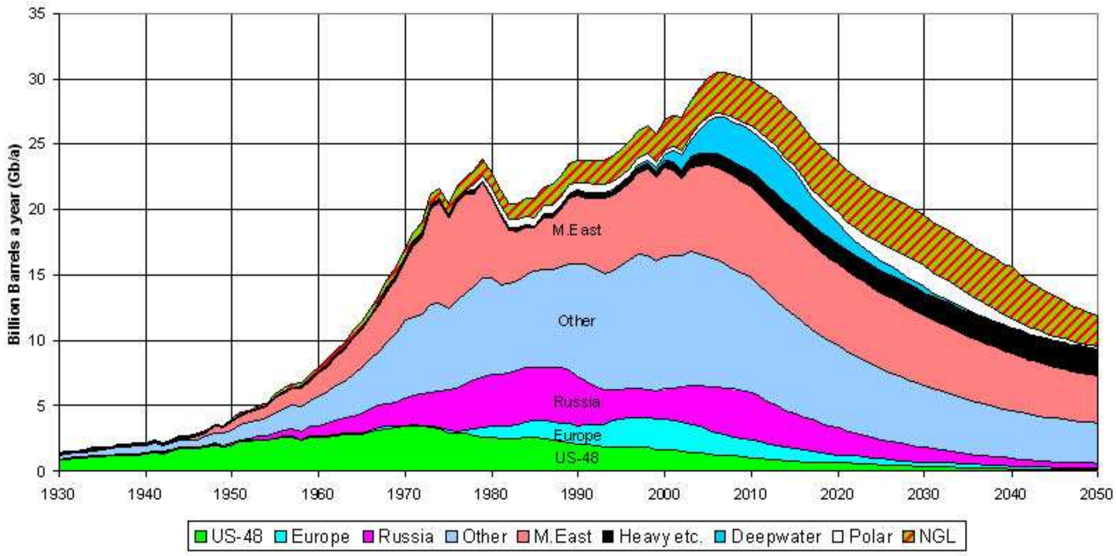

Figure F: The 2004 oil and gas liquids as presented by Uppsala Hydrocarbon Depletion Study Group

Source: www.peakoil.net/uhdsg/weo2004/TheUppsalaCode.html

This graph illustrates where future oil and gas production may come from. The graphic assumes that oil from Deep water, Polar Regions and Natural Gas Liquids is included in the outlook as part of different countries production of oil. Further it is assumed that the Middle East will maintain the "sustainable production scenario". Production from tar sand will continue, but the increase will be slower than IEA. The increase in the polar production around 2030 is from discoveries not yet made, in the belief that as drilling starts in Alaska, something will be found in Russia.

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NZ HERALD

US$200 oil by year 2030 predicts IEA

The International Energy Agency has nearly doubled its forecast for the price of oil over the next 20 years, citing rising demand in the developing world as well as surging costs of production.

According to a summary of the agency's World Energy Outlook report due to be published next week, the IEA has hiked its forecast for the price of a barrel of oil in 2030 to just over US$200 ($340) in nominal terms, compared with its forecast last year of US$108 a barrel. Measured in constant dollars, the IEA forecasts oil at US$120 a barrel in 2030, up from last year's forecast of US$62.

The predictions come after crude oil prices touched a peak of US$147.27 a barrel in mid-July before diving 56 per cent to trade around US$65 yesterday.

The IEA — an energy policy adviser for its 26 member countries, including the United States, Canada, Australia, Germany and Britain, as well as 17 other European countries — said spending on oil as a share of global economic output would rise to 5 per cent over the period, compared with 4 per cent last year.

"The only time the world has ever spent so much of its income on oil was in the early 1980s, when it exceeded 6 per cent," the IEA said.

The IEA cut its forecast for global oil demand growth to 1 per cent a year on average over the next two decades.

It now sees demand growing from 85 million barrels a day last year to 106 million barrels a day in 2030. That compares with last year's forecast of 116 million barrels a day by 2030.

Higher prices, slower economic growth and Government policies over the past year have helped cool demand in the developed world. Nearly all the growth in demand for oil over the period would come from China, India, and the Middle East, the IEA said.

> **The world's energy system is at a crossroads. Current global trends in energy supply and consumption are patently unsustainable.**
>
> INTERNATIONAL ENERGY AGENCY

Demand for all forms of energy is forecast to grow 1.6 per cent a year over the period to around 17 billion tonnes of oil equivalent a year, with half the new demand coming from just two countries: China and India.

Last year, the IEA forecast energy demand to grow 1.8 per cent annually over the period.

Despite the lowered growth forecast, the IEA lifted its estimate of the investment in energy infrastructure needed to meet the rising global demand for energy by 2030. It said the world needed to invest US$26 trillion over the period, US$4 trillion more than last year's forecast.

The agency said there would be enough oil for decades to come but warned that global prosperity and the state of the planet hang on radical change in energy production and use.

"The world's energy system is at a crossroads. Current global trends in energy supply and consumption are patently unsustainable — environmentally, economically, socially.

"But that can — and must — be altered: there's still time to change the road we're on.

"The future of human prosperity depends on how successfully we tackle the two central energy challenges facing us today: securing the supply of reliable and affordable energy and effecting a rapid transformation to a low-carbon, efficient and environmentally benign system of energy supply."

The IEA pointed to huge strides being made in electricity production, and projected that "modern renewable technologies grow most rapidly, overtaking gas to become the second-largest source of electricity, behind coal, soon after 2010". *AP, AFP*

Item 4 – There are indications that world oil consumption may be influenced by economic conditions. The US has witnessed a 4% decline in transport fuel consumption, and Japan an even greater decline over the past year. Some of this may be attributed to cyclone damage and associated loss of economic productivity.

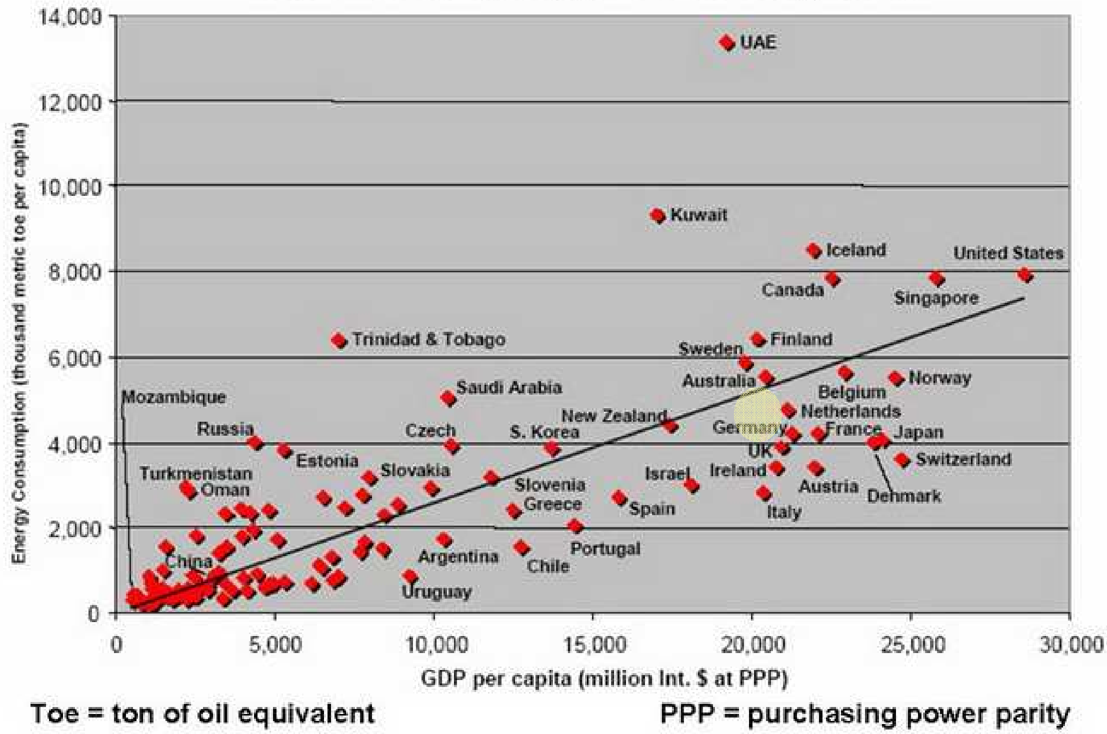


Figure G: GDP vs. Energy intensity in various countries

Source: http://www.iea.org/textbase/nppdf/free/2008/key_stats_2008.pdf).

This graphic suggests that there is a strong relationship between energy intensity and economic activity. It is postulated that resource depletion will result in comparative energy prices increases, will more strongly adversely affect those countries with higher energy intensity per GDP.

Item 5 – It is suggested that technical (e.g. low resistance tyres, GPS traffic systems, regenerative breaking) and behaviour change (e.g. purchasing smaller cars, higher vehicle occupancy) might reduce the average fuel consumption of new vehicles.

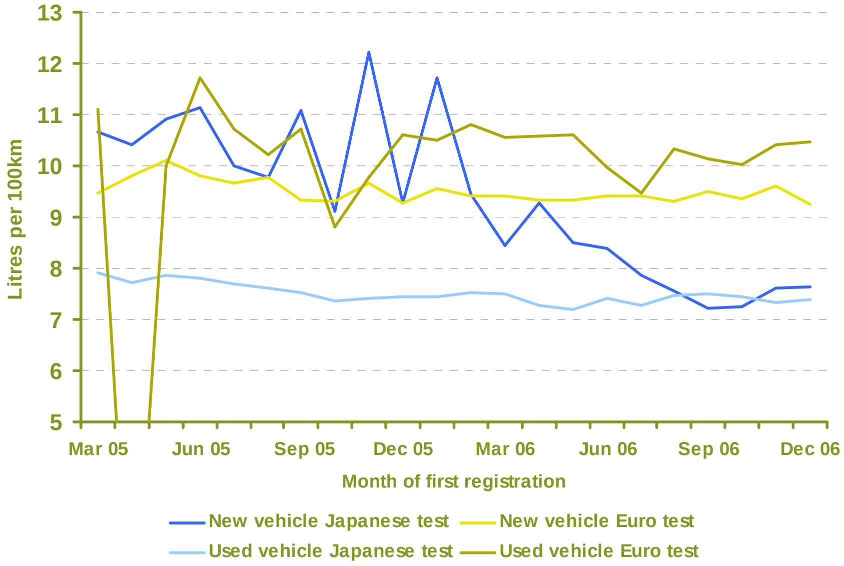


Figure H: Average New Zealand vehicle petrol consumption trend

Source: Ministry of Transport, 2008.

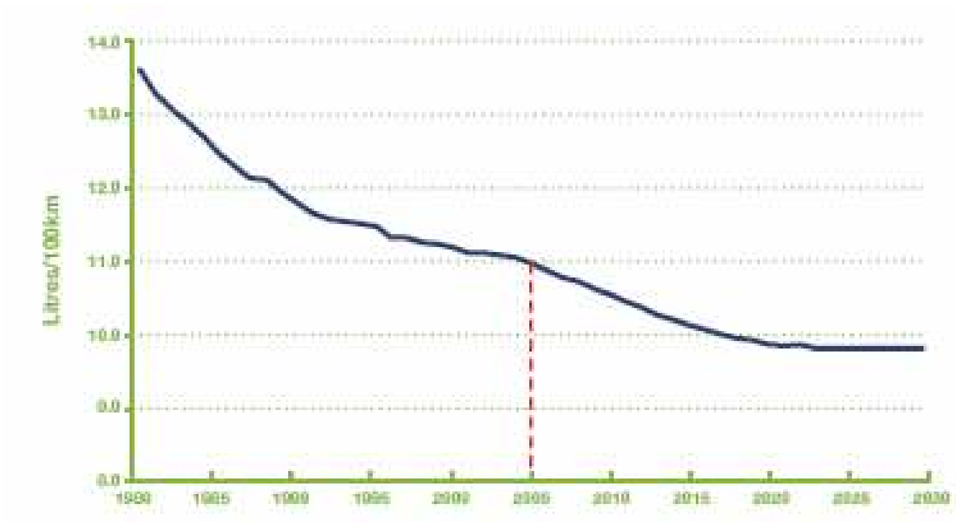


Figure I: Average New Zealand vehicle petrol consumption trend

Source: Ministry of Transport, 2008.

The sample and time span of ‘new vehicle’ fuel economy is not sufficient to draw conclusions.

Based on current rates of fleet turn-over it will take between 8 and 10 years for ‘new vehicle’ economies to be seen in the fleet economy.

Item 6 – If oil access is restricted, oil production from coal, gas and biomass could be achieved. The total oil production possible from these resources is considerably greater than total historic oil production. These production methods also increase GHG emissions.

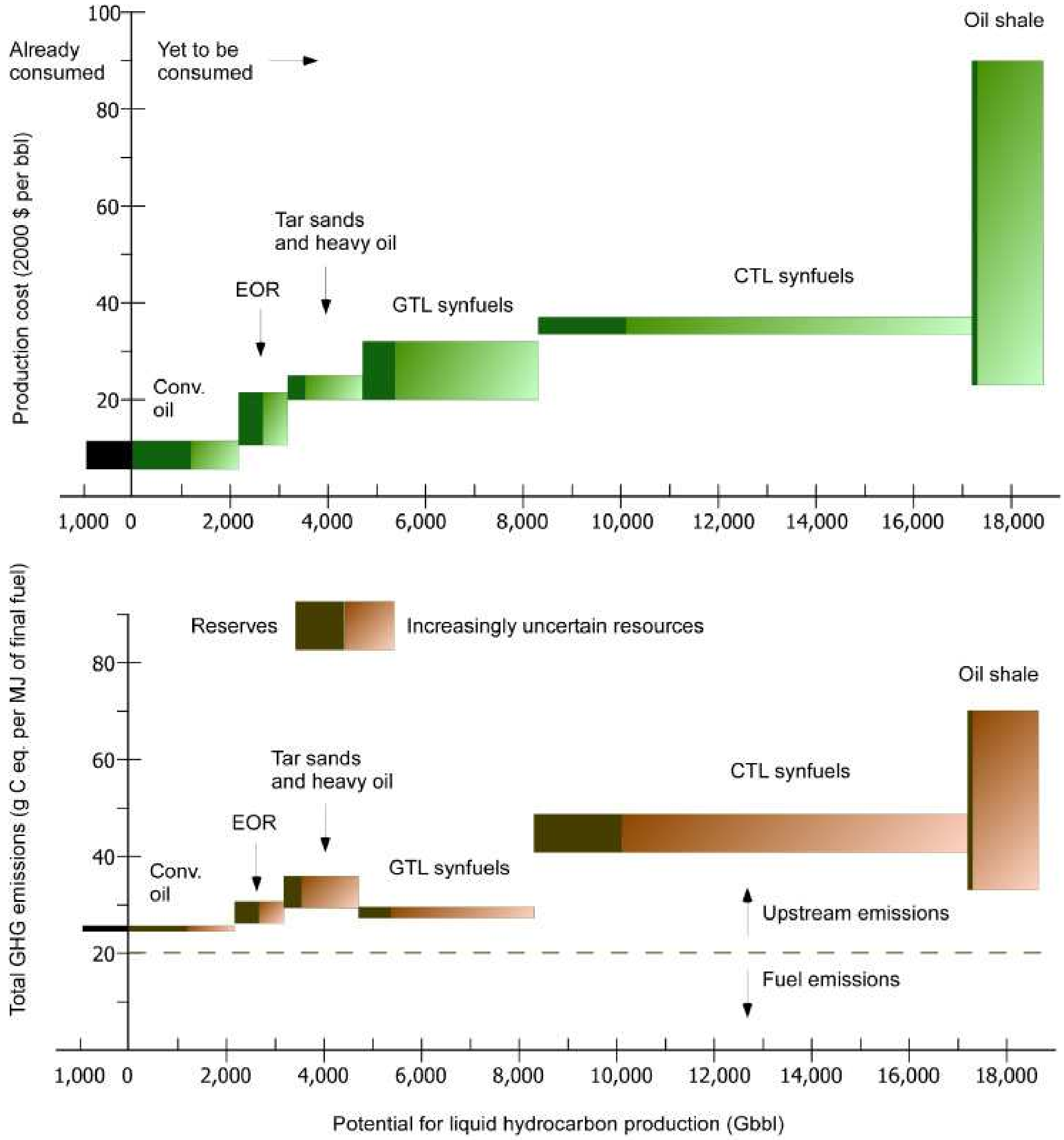


Figure J: Global supply of liquid hydrocarbons from all fossil resources and associated costs in dollars (top) and GHG emissions (bottom)

Source: Farrell and Brandt (2006)

The two graphs show the oil already consumed (black to the left of the y-axis) and the quantities in reserves and uncertain resources (to the right). The production costs (top) and GHG emissions

EOR is enhanced oil recovery, GTL and CTL are gas-and coal-derived synthetic liquid fuels. The CTL and GTL quantities are theoretical maxima because they assume all gas and coal are used as feedstock for SCPs and none for other purposes. The lightly shaded portions of the graph represent less certain resources. GHG emissions in the lower figure are separated into fuel combustion (downstream) and production and processing (upstream) emissions by a dashed line. Results are based on costs and conversion efficiencies of current technologies available in the open literature. Gas hydrates are ignored due to a lack of reliable data. The GTL cost estimates assume a range of $0.5 to $2 per MBTU.

New Zealand was once considered to be a gas exploration basin, has significant coal (lignite) reserves, and has significant biomass growing potential, so could well establish an alternative oil production system.

Item 7 – The New Zealand government is targeting an increase in active transport from 17 to 30% of all trips by 2040. The Auckland regional council believes it is unsafe to increase active transport so is not targeting an increase in active transport.

Item 8 – Changing urban form is potentially one the most significant influences on transport energy consumption, and is the often the factor that defines the different transport energy intensities of different countries. New Zealand has few active programs reviewing urban form impact on transport energy requirements.

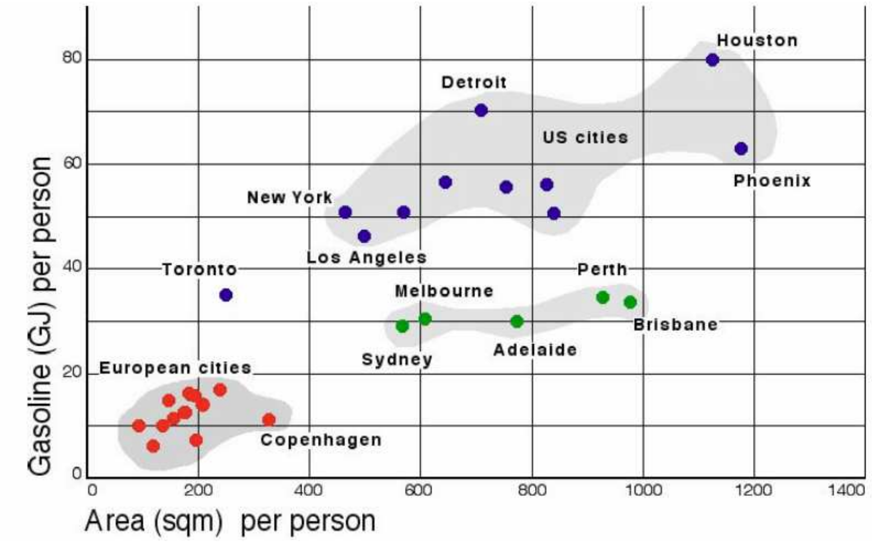


Figure K: Relationship between urban footprint and fuel consumption

Source: http://www.cnu.org/sites/files/Dittmar.pdf

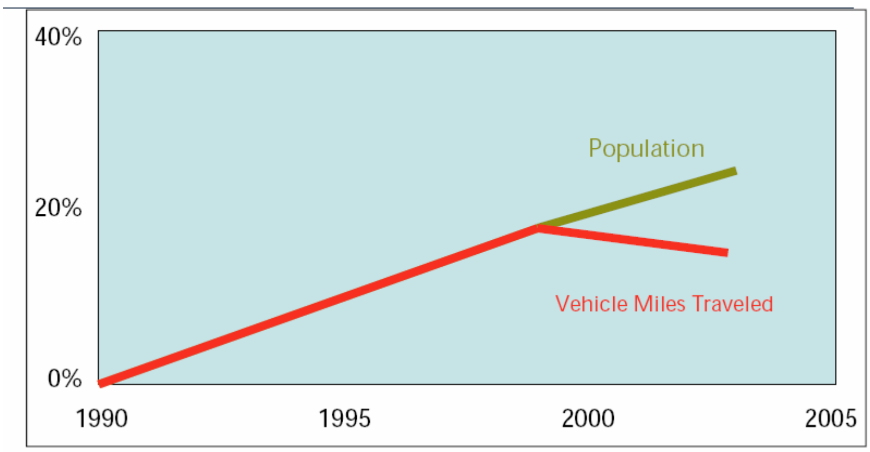
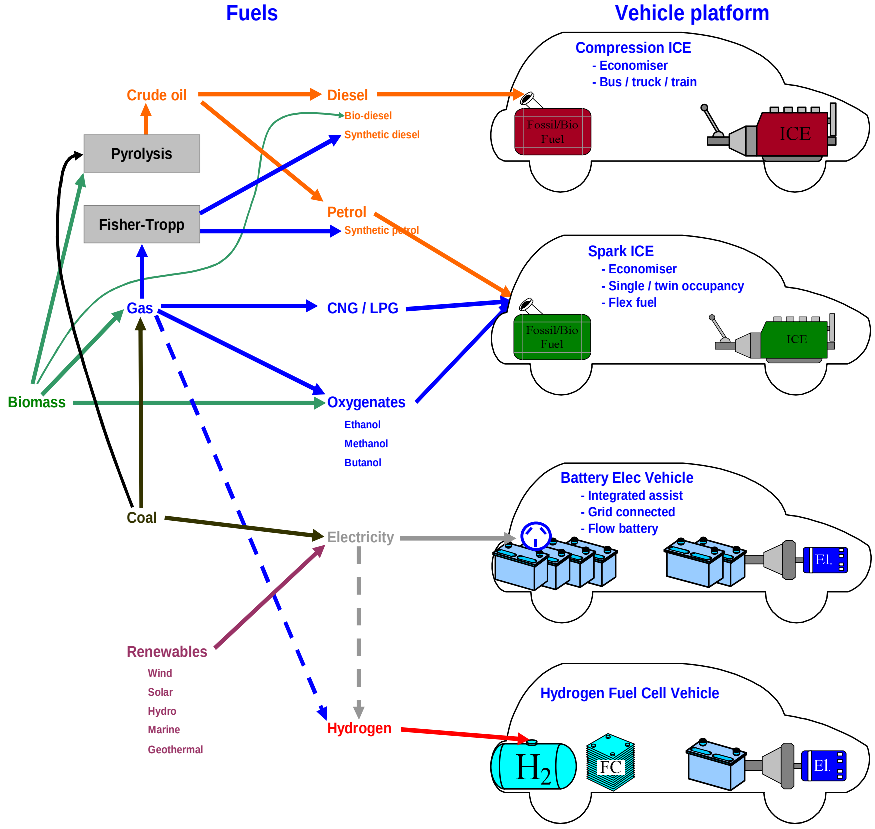


Figure L: Relationship between vehicle traffic growth and population in Portland Metropolitan area

Source: http://www.cnu.org/sites/files/Garrick.pdf

Item 9 – Electric vehicles enable substitution of energy source for passenger transport to shift from petroleum to electricity. If electricity is sourced from renewable sources, this could dramatically reduce the emissions intensity. Electric vehicles are unlikely to provide a significant proportion of freight transport services.



Compression ICE

		2009	2030
Cost of operation (CAPEX, 10 yrs fuels; $50/t$CO_2$)		**39,822**	**48,622**
Base price	$	19,950	18,375
Energy efficiency	MJ/km	2.53	0.9
Fuel cost (base)	$/MJ	0.028	0.190
Fuel cost (inc. tax)	$/MJ	0.044	0.270
Annual fuel	$/y	1,819	2,920
GHG Emssions	gCO_2/km	207	175
GHG Emssions	tCO_2/y	3.37	2.10

Spark ICE

		2009	2030
Cost of operation (CAPEX, 10 yrs fuels; $50/t$CO_2$)		**57,769**	**60,037**
Base price	$	19,000	17,500
Energy efficiency	MJ/km	3.38	0.9
Fuel cost (base)	$/MJ	0.045	0.305
Fuel cost (inc. tax)	$/MJ	0.066	0.385
Annual fuel	$/y	3,659	4,158
GHG Emssions	gCO_2/km	268	160
GHG Emssions	tCO_2/y	4.37	1.92

Battery Elec Vehicle

		2009	2030
Cost of operation (CAPEX, 10 yrs fuels; $50/t$CO_2$)		**57,123**	**27,464**
Base price	$	50,000	21,000
Energy efficiency	MJ/km	0.67	0.44
Fuel cost (base)	$/MJ	0.060	0.082
Fuel cost (inc. tax)	$/MJ	0.064	0.121
Annual fuel	$/y	700	637
GHG Emssions	gCO_2/km	15	15
GHG Emssions	tCO_2/y	0.24	0.18

Hydrogen Fuel Cell Vehicle

		2009	2030
Cost of operation (CAPEX, 10 yrs fuels; $50/t$CO_2$)		**203,877**	**27,843**
Base price	$	200,000	22,000
Energy efficiency	MJ/km	1.33	0.67
Fuel cost (base)	$/MJ	0.006	0.009
Fuel cost (inc. tax)	$/MJ	0.015	0.068
Annual fuel	$/y	320	548
GHG Emssions	gCO_2/km	83	60
GHG Emssions	tCO_2/y	1.35	0.72

Figure M: Comparison of vehicle types, and future cost of operation

Source: EnergyScape 2008

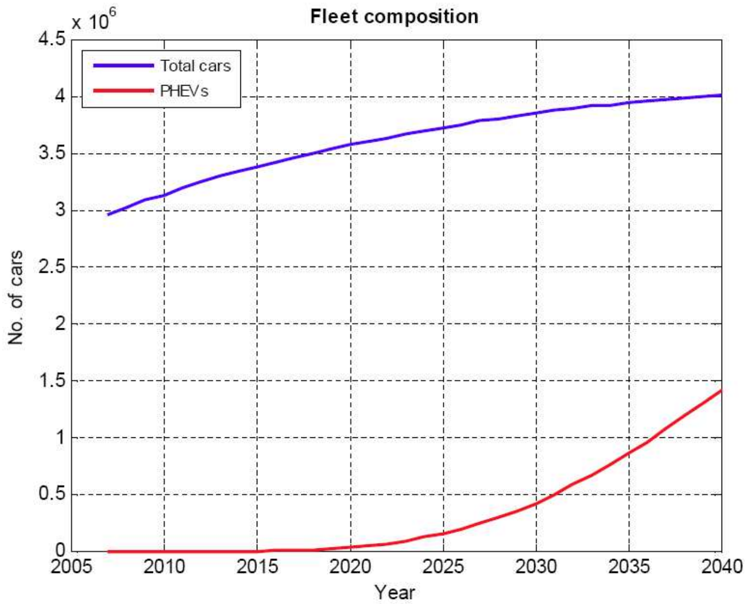


Figure N: Projected (electric) vehicle fleet composition

Source: Impact of Plug-in Hybrid Vehicles on the New Zealand Electric Grid
Erwan Hemery and Bruce Smith, 31 March 2008

Although electric vehicles are available for purchase now, the makers of the graph expect a significant uptake only to happen many years later.

Item 10 – Crude oil price is responsive to a wide range of influences. Historically prices have responded to changes in the demand-supply balance associated with political instability. It is speculated that recent price spikes are attributed to an increase in oil scarcity relative to demand.

Figure O: Factors influencing real crude oil prices (1970 – 2008)

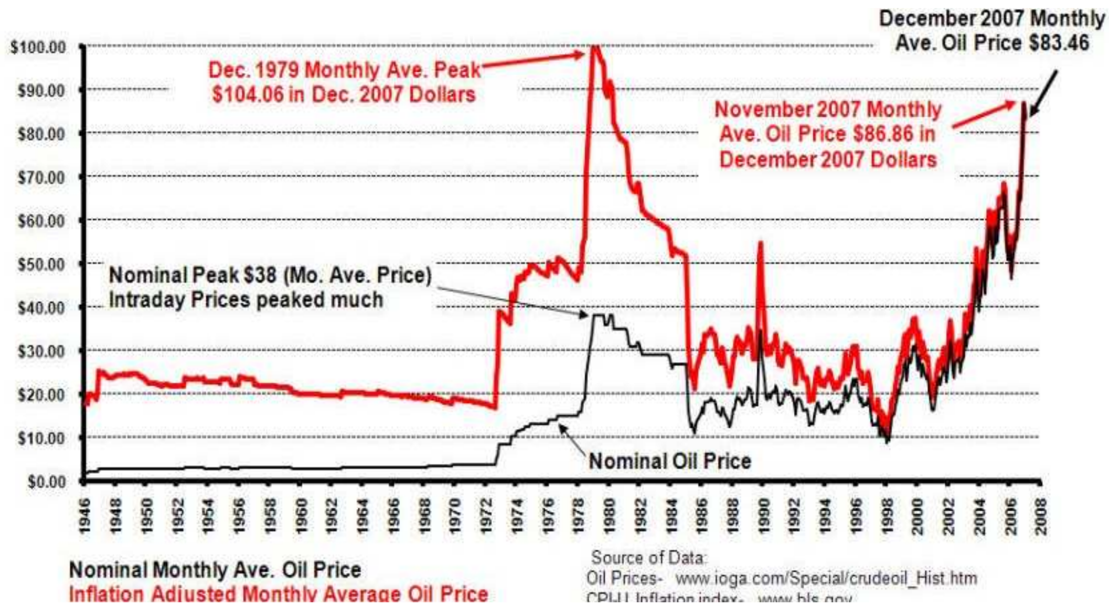


Figure P: Long term oil price development not inflation adjusted (top) and inflation adjusted (bottom)

Source: http://www.crudeoilprice.com/Crude-oil-prices-1970-2008.gif and http://www.crudeoilprice.com/Inflation-adj-oil-prices-chart.jpg (accessed 23-10-2008)

Figure Q: Recent oil price development

US Energy Information Administration (http://tonto.eia.doe.gov/dnav/pet/hist/rbrted.htm, accessed 23-10-2008)

GAS SECTOR INFORMATION

Item 11 – New Zealand's economic prosperity has for many years been supported by access to cheap gas, in particular from the Maui (4,100 PJ and ~200 PJ/y) field.

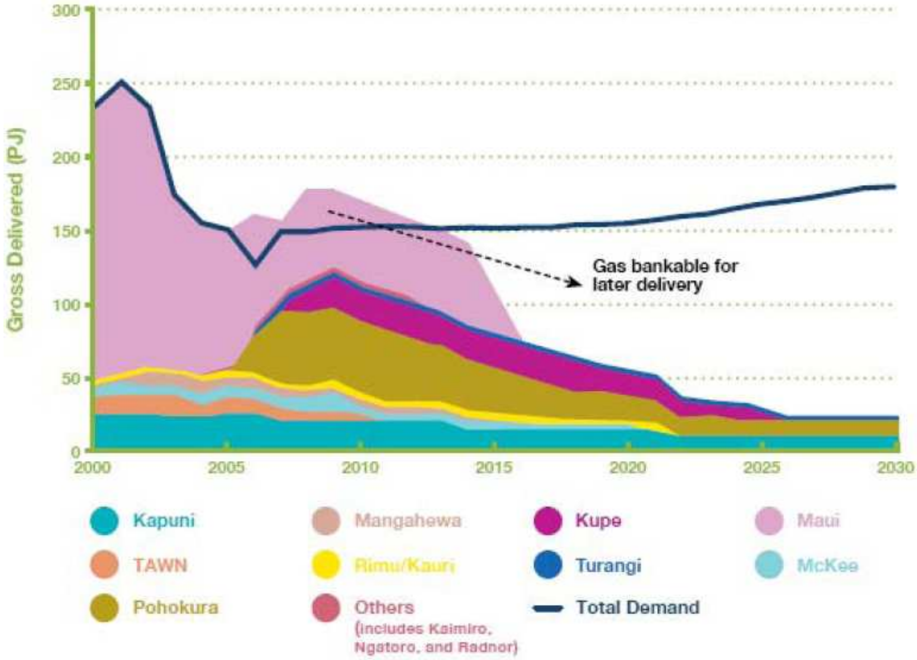


Figure R: Estimated production profile based on current discovery

Source: MED Energy Outlook to 2030

After the re-determination of Maui in 2003 industrial activity (e.g. Methanex) slowed production and demand. Even with the reduced consumption rates, the outlook of gas supply meeting gas demand is short-lived.

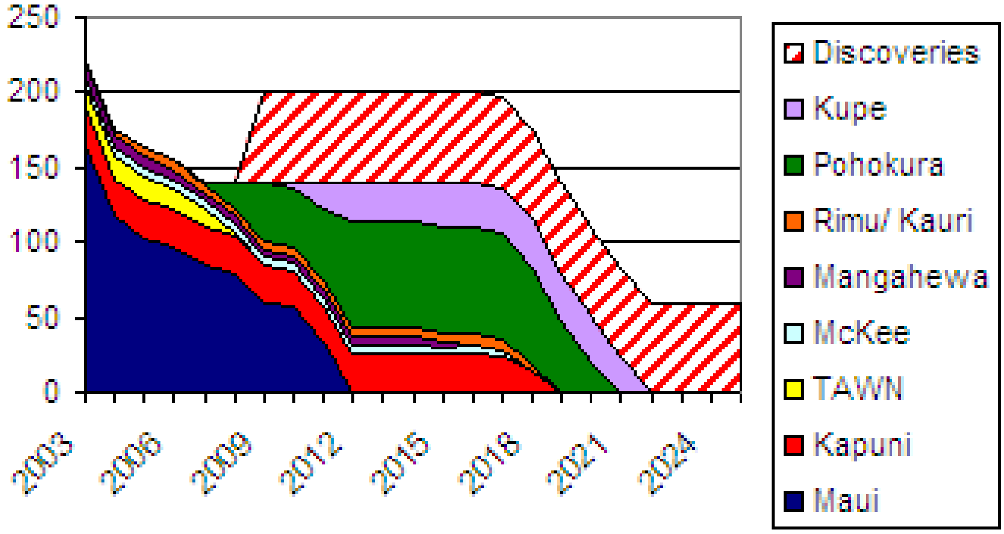


Figure S: Potential delay in gas shortage, based increased exploration

MED assume that with increased interest in gas exploration, a 60 PJ/y gas discovery rate is possible. The current national demand is around 150 PJ/y.

Item 12 – A significant proportion of gas use is for fertiliser and methanol production. These production systems enable New Zealand to profit from gas exploration. If international demand / prices for methanol and fertiliser continue to increase, the demand of gas will also increase.

Figure T: World oil and methanol prices

Source: Methanex

International methanol prices have driven Methanex from lowest price gas bidder to highest price gas bidder.

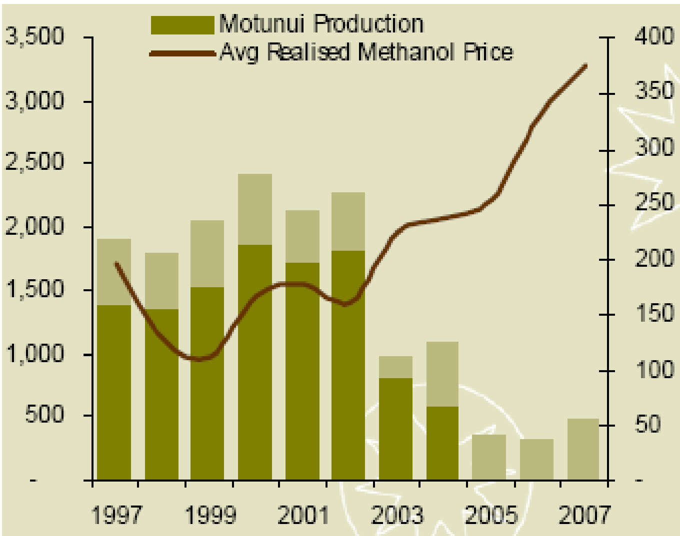


Figure U: Methanex New Zealand production and pricing

International methanol prices have stimulated Methanex to re-start methanol production. The gas supply-demand balance will therefore contract, with the following potential outcomes:

- Potential shortfall before 2015 if Methanex runs for long even with 60 PJ/y discovery rate.
- Shortfall not too far after 2015 even without Methanex running.
- Contact Energy got little response from the RFP for gas to Otahuhu C.
- Expectation that there will be little extra gas after 2015 or just unwillingness to price gas at that horizon?

Ultimately, shortfall will depend on Methanex and how big new discoveries will be – and where they will be located?

Item 13 – The electricity generation sector use gas to support existing assets. As gas supply tightens these assets either become unprofitable or pass on higher electricity pricing to the market.

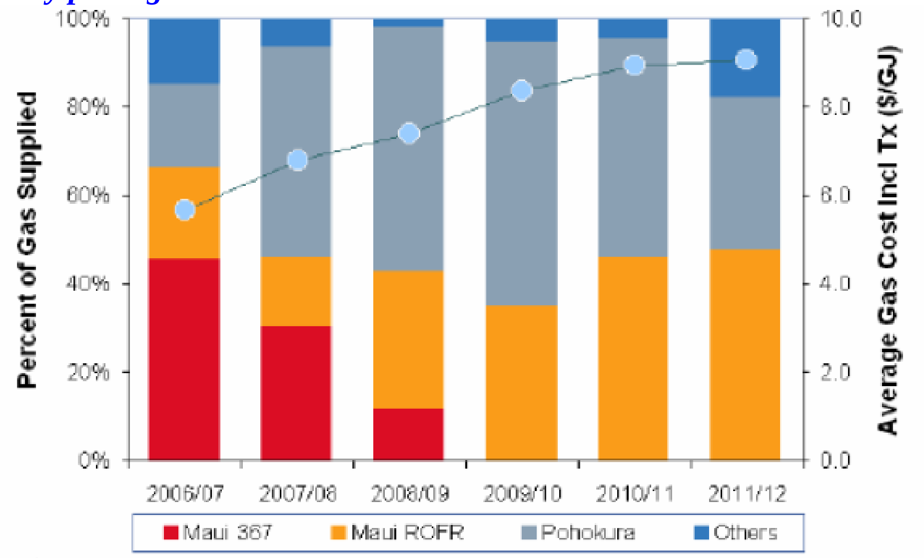


Figure V: Gas price forecast by electricity generator

Source: www.contact-energy.co.nz

As electricity generators move from Maui contracts to contestable contracts the wholesale price of gas has shifted upward from just above 7 $/GJ in excess of 9 $/GJ. If gas supply tightens, the price could well increase.

Item 14 – LNG imports will only be economically viable if domestic gas price remains above import price for a sustained period. Because New Zealand would only be a small consumer (in world terms) it would not sustain a permanent shipping route, therefore would have to buy from "non-permanent" contract market.

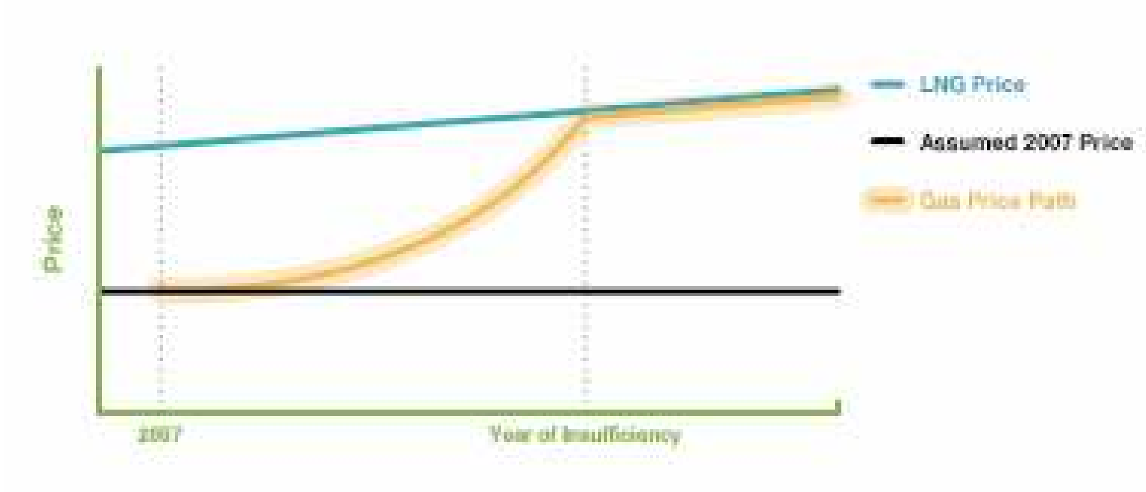


Figure W: Gas price forecast by electricity generator

Less than 10 "non-permanent" contract LNG sales have ever been made. Prices for these sales have typically been >12 $/GJ.

ELECTRICITY SECTOR INFORMATION

Item 15 – The future of the electricity sector has some influences that are likely to increase grid-supplied electricity demand (e.g. electric vehicles, new appliances), and some that are likely to decrease grid-supplied (e.g. Solar hot water and photovoltaic installations, energy efficiency e.g. insulation, Compact lighting).

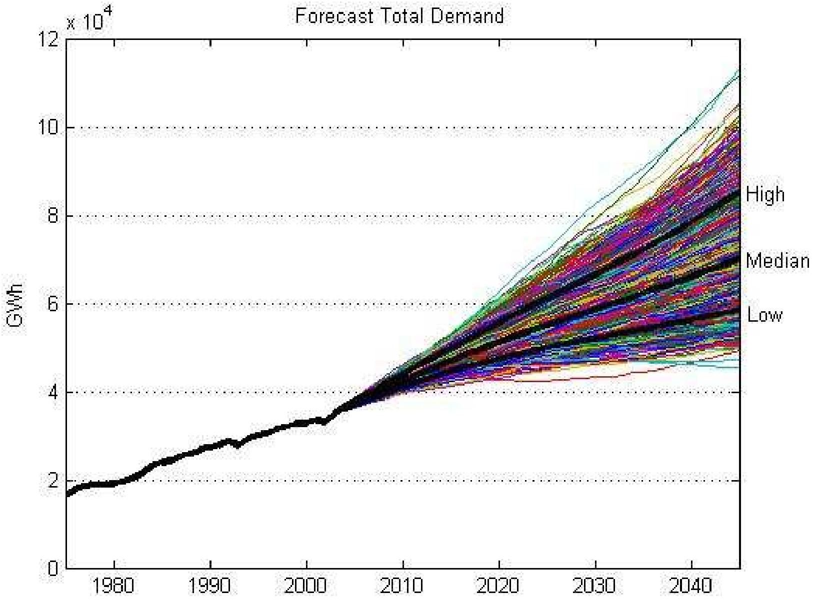


Figure X: Electricity demand forecast (New Zealand).

Source: http://www.electricitycommission.govt.nz/opdev/modelling/pdfsmodelling/total-forecast.jpg

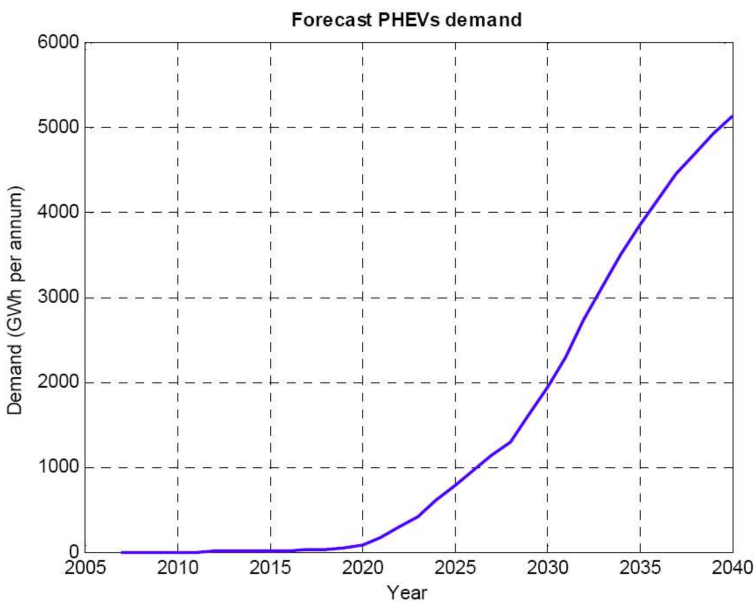


Figure Y: Projected (electric) vehicle fleet electricity demand (bottom).

Source: Impact of Plug-in Hybrid Vehicles on the New Zealand Electric Grid
Erwan Hemery and Bruce Smith, 31 March 2008

GHG EMISSIONS INFORMATION

Item 16 –The transport and storage phases of carbon capture and sequestration (CCS) technology are reasonably developed at commercial scale. The separation technology has been demonstrated, but is still not cost effective.

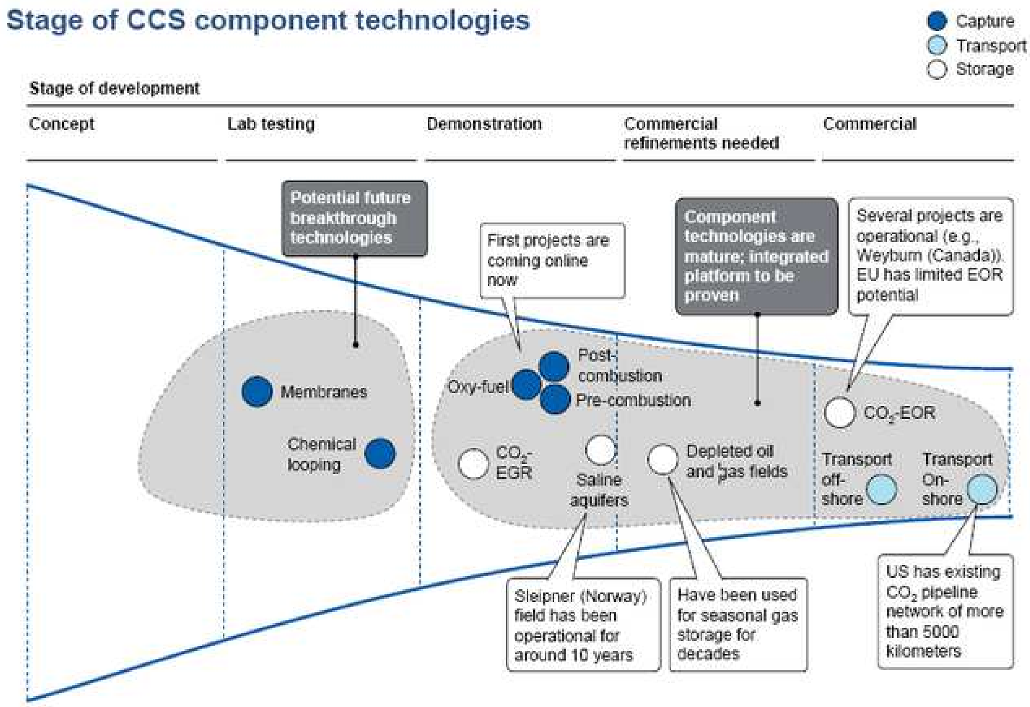


Figure Z: Stages of CCS component technologies

Source: McKinsey

CCS costs in the reference case scenario down to around €30-45 (US$43-65) per tonne of CO_2 abated by 2030—costs which are in line with expected carbon prices in that period. Early CCS demonstration projects will have a significantly higher cost of €60-90 per tonne, according to the report. Early full commercial-scale CCS projects—potentially to be built soon after 2020—are estimated to cost €35-50/tonne CO_2 abated.

Item 17 – There is still much uncertainty regarding the likely price of greenhouse gas emission pricing in New Zealand.

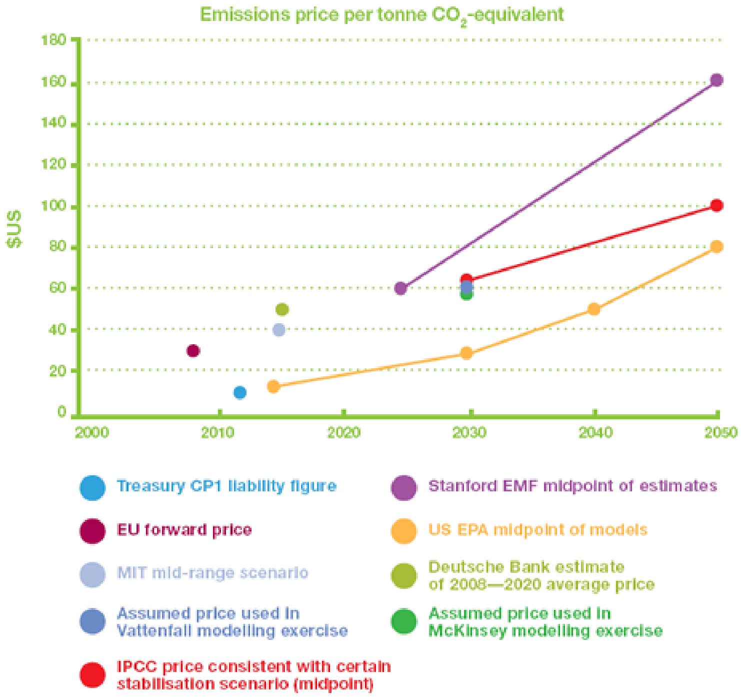


Figure AA: GHG emission pricing according to MED

Source: MED, New Zealand Energy Strategy to 2050 – Powering Our Future, http://www.med.govt.nz/templates/MultipageDocumentPage____32076.aspx

Exactly what the international price of greenhouse gas emissions might be in the future is the subject of a large amount of speculation and conjecture. By its very nature, the future price of emissions is a great unknown, due to profound uncertainties about the international regulatory regime, technology developments and global economic growth and income distribution. The current market price estimate used by the New Zealand Treasury in the government's 2007 financial statements is US$ 11.90 per tonne CO_2 equivalent.

Item 18 –The long term cost of GHG emissions is expected to reach or just exceed the cost of abatement.

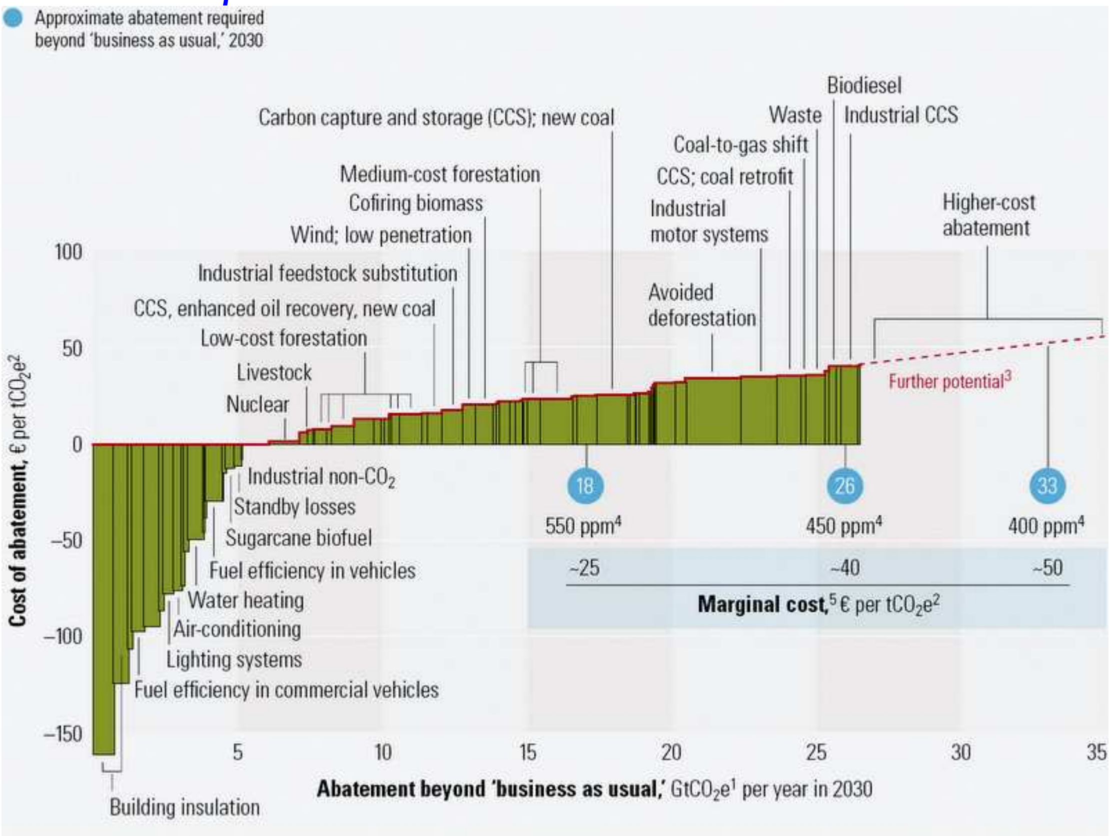


Figure AB: Global cost curve for greenhouse gas abatement measures beyond "business as usual".

Source: Enkvist et al., McKinsey & Company, 2007

Notes:
(1) $GtCO_2e$ = gigaton of carbon dioxide equivalent;
"business as usual" based on emissions growth driven mainly by increasing demand for energy and transport around the world and by tropical deforestation.
(2) Marginal cost of avoiding emissions of 1 ton CO_2 equivalents in each abatement demand scenario.
(3) The annual abatement needed to achieve stable atmospheric greenhouse gas concentrations of 500 ppm (parts per million), 450 ppm and 400 ppm of CO2-equivalents.

A number of means of estimating longer-term emissions prices have been employed by various bodies. For example, Vattenfall and McKinsey have inferred future emissions prices on the basis of derived global carbon abatement cost curves. Estimates of US$30 per tonne for 2030 were produced.

The Intergovernmental Panel on Climate Change Working Group, in its draft fourth assessment report, estimates the emissions prices associated with various atmospheric greenhouse gas stabilisation scenarios. The stabilisation scenario consistent with a maximum global temperature increase of 2ºC produced a price of US$ 100 in 2030.

Various modelling simulations and comparative analyses have also been undertaken by universities and think tanks, producing a wide range of estimates. Generally, these techniques have produced estimates with very large standard errors.

The diversity in estimates of future greenhouse gas emissions prices reflects the profound uncertainty of related factors. However, most commentators in this area broadly seem to expect the price of emissions to rise over time.

Acknowledgement

NIWA wish to acknowledge Magnus Hindsberger of Transpower, for allowing EnergyScape to adapt the questionnaire concept that he developed for the T2040 project. We found the probability questionnaire approach to be a very useful mechanism for stimulating discussion and channelling consensus.