New Zealand's Energy Outlook 2010

Reference Scenario and Sensitivity Analysis

Welcome

The 2010 edition of New Zealand's *Energy Outlook* presents updated projections of New Zealand's future energy supply, demand, prices and greenhouse gas emissions. These projections are principally aimed at informing the energy debate.

This article includes results from the *Reference Scenario and Sensitivity Analysis*.

The *Reference Scenario* provides a benchmark with which to compare other sensitivity cases and alternative scenarios. The *Reference Scenario* is not our expectation of what is going to happen.

Rather, it starts from an assumption of business as usual continuing in terms of broad trends in key economic drivers, policy settings, and technology and fuel choices. The *Reference Scenario* uses central forecasts of population, gross domestic product (GDP), and New Zealand dollar exchange rates, and assumes continuation of enacted government policies such as the emissions trading scheme. Detailed assumptions are discussed at the end of this article.

The second part of this article presents analysis which explores the sensitivity of the *Reference Scenario* to the key macroeconomic variables of economic growth (GDP), exchange rate, emissions price and oil price.

This article is supported by detailed data tables available on the Ministry of Economic Development (MED) website.

Key messages from the Reference Scenario and Sensitivity Analysis

Reference Scenario

- Consumer energy demand is projected to grow at 0.9% per annum to 2030, lower than the 1.4% p.a. seen from 1990.
- New Zealand's energy intensity improves 22% by 2030.
- In 2030, renewable energy sources provide 50% of New Zealand's energy supply.
- Total energy sector emissions stabilise but remain more than 40% above 1990 levels in 2030.
- Emissions from transport continue to grow while emissions from electricity decline.
- Wholesale electricity prices may need to rise 29% by 2030 in order to support investment in new generation.

Sensitivity Analysis

- Higher economic growth increases New Zealand's energy consumption but also triggers greater energy intensity improvements. Energy intensity improves 29% by 2030 in the high economic growth sensitivity case.
- Emissions in 2030 are over 50% higher than 1990 levels in the high economic growth sensitivity case.
- Sustained higher oil prices encourage the purchase of more fuel-efficient vehicles and a greater uptake of electric vehicles and locally produced biofuels.
- An emissions price of $100 per tonne results in only limited additional emissions reductions compared with the *Reference Scenario*.
- A higher valued New Zealand dollar improves the economics of imported technology (e.g. wind turbines) and results in lower wholesale electricity prices.

Want a closer look?

For detailed data visit
www.med.govt.nz/energyoutlook

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Ministry of Economic Development
Manatū Ōhanga

Key Indicators

Detailed Data Tables Available at:
www.med.govt.nz/energyoutlook

Reference Scenario

Energy intensity reflects the relationship between energy use and GDP and is influenced by both the composition of industry within an economy and energy efficiency improvements.

Energy demand in New Zealand has steadily increased between 1990 and 2009 along with a growing population and the economy. Along the way, we have progressively reduced the amount of energy it takes to produce each "unit" of GDP by an average of 1.3% per year. This is a result of advances in technology, energy efficiency and conservation measures, and structural changes in the economy. Much of the economy's recent growth has been in the less energy-intensive service-based sectors. For example, retail trade, communication services, finance and insurance, and real estate and business services have accounted for almost 50% of the increase in GDP since 1990.

Without these improvements in energy intensity, energy demand would now be much higher. In the *Reference Scenario*, the historical rate of energy intensity improvement is expected to continue at 1.3% per year between 2010 and 2030. This continual improvement flows from the uptake of new, efficient technology in households, industry and commerce, and transport. Higher energy costs are also expected to increase the range of economic energy saving options. For example, recent high fuel prices and overseas trends towards efficient light vehicles appear to be influencing New Zealand's vehicle choices and have halted our previous tendency towards larger vehicles.

By 2030, New Zealand's energy intensity is expected to have improved from around 4GJ per $1,000 of GDP to 3GJ per $1,000 of GDP. Over this time the central economic growth forecast is for an average rate of 2.3% p.a. whilst consumer energy grows at just 0.9% p.a.

Over half of the expected reduction in energy intensity occurs in transport. Historical travel data indicates that personal road travel has already reached near saturation level with little additional per capita travel likely. Thus, future personal travel demand is expected to grow in line with population growth at 0.8% p.a. to 2030 and well below GDP growth. On top of this we expect light fleet efficiency improvement of close to 20% over this time. Road freight and other business-related travel is more closely aligned with GDP growth.

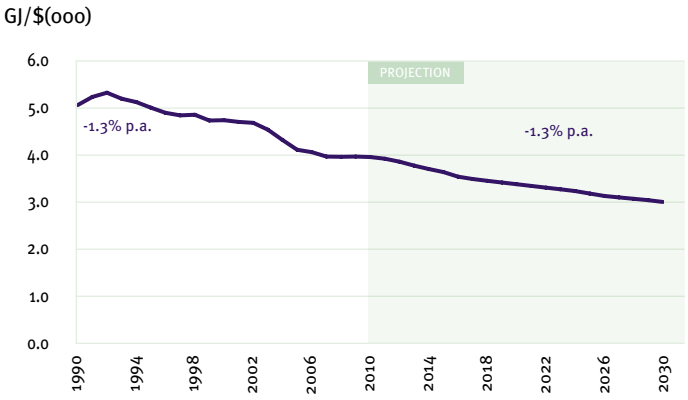
Primary fossil fuel demand provides an indication of how reliant on fossil fuels a country is.

New Zealand's fossil fuel demand experienced strong growth up until a peak in 2001, driven by growing demand for transport fuel and natural gas for methanol production and electricity generation. Since 2001, fossil fuel consumption has been largely flat over a period which saw higher prices for gas and oil, and the effect of the recent recession.

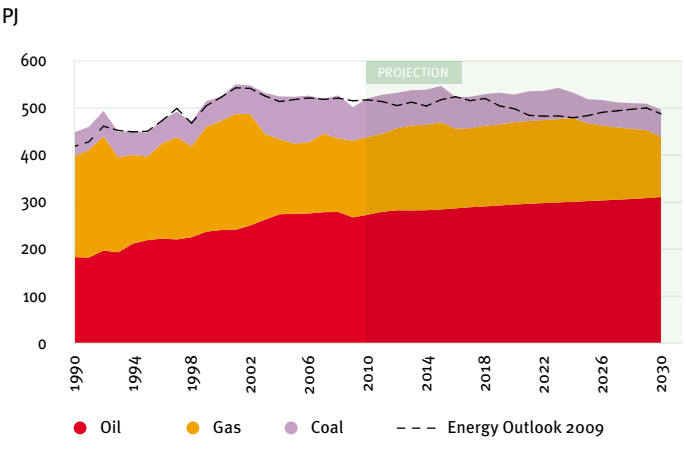
Looking ahead to 2030, total demand for fossil fuels remains relatively flat in the *Reference Scenario*. The increase in transport's demand for oil products is initially offset by reductions in coal used in electricity generation, and in the late 2020's by reductions in gas use as supply tightens.

Although still fairly flat, projected fossil fuel demand is higher than that seen in last year's *Reference Scenario* with increases in the gas supply assumptions. Existing gas reserves have increased by some 300PJ since last year following the start of production at Kupe in December 2009. In addition, the modelled level of gas production from new discoveries has also increased from *Energy Outlook 2009*. This is described in the assumptions section.

Consumer Energy Intensity – Reference Scenario



Primary Fossil Fuel Demand by Fuel Type



Reference Scenario

Energy sector greenhouse gas emissions have grown by 35% since 1990 as result of strong growth in transport demand and the increased use of coal and gas in electricity generation. In recent years, total emissions have flattened, and electricity generation emissions fell to a seven year low in 2009 (with new geothermal and wind generation commissioned and favourable hydrological conditions).

In the *Reference Scenario*, emissions from electricity generation remain relatively flat over the next few years and reduce significantly after 2015 as increasing amounts of renewable generation are built and Huntly units are progressively phased out.

Emissions from manufacturing industries increase slightly above historical rates, driven by growth in dairy, wood processing and light industry. Emissions from transport, transformation industries and other sectors are also projected to grow, albeit at lower than historical rates.

In total, energy sector emissions remain flat in the *Reference Scenario*. This is achieved through the emissions reductions seen in the electricity sector, where 83% of generation is from renewable sources by 2030. The key challenge to lowering emissions remains the transport sector, in which emissions are seen to grow in the *Reference Scenario* to 48% of total energy emissions by 2030. Note that this *Reference Scenario* includes the effect of an emissions price of NZ$50 per tonne of carbon dioxide equivalent (CO_2-e).

Emissions in this *Reference Scenario* are generally in line with those projected in *Energy Outlook 2009*. The increased availability of natural gas that is now seen offsets some coal used for electricity generation in the near term, which reduces emissions between 2015 and 2020. From 2020 to 2025, however, this additional gas generation delays the build of some renewable electricity generation to later in the decade.

Wholesale electricity prices have increased substantially in recent years, reflecting both the increased costs of operating existing gas power stations and the costs of building new wind and geothermal generation.

Modelling for the *Energy Outlook* determines the most economic mix of new generation that can meet expected demand growth. The wholesale electricity price indicator shows the direction of future prices if investors were to earn an economic return on this new generation.

In the *Reference Scenario*, the wholesale price indicator remains relatively static for the next few years, with geothermal and some of the higher quality wind projects economic at current wholesale price levels. It should be noted that the economics of wind and geothermal are highly dependent on steel prices and exchange rates, which are both relatively favourable at the time of writing this article. By 2020, the wholesale price indicator rises towards $100/MWh as more expensive wind, hydro and geothermal stations are required to meet demand growth.

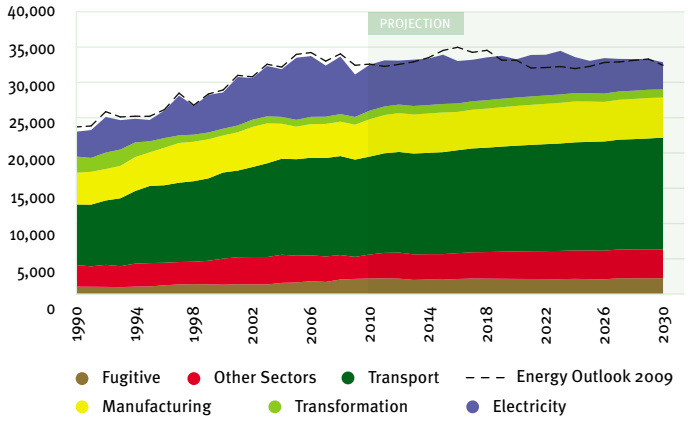
The increased wind and geothermal generation in the *Reference Scenario* implies the need for more peaking generation. Accordingly, almost 900MW of additional gas and diesel peaking generation by 2030 is seen in this *Reference Scenario*.

Comparisons of Key Assumptions between the 2009 and 2010 Reference Scenarios

Assumption	2009 Reference Scenario		2010 Reference Scenario	
	2020	2030	2020	2030
GDP (average % p.a.)	2.6	2.3	2.4	2.2
Population (millions)	4.7	4.9	4.8	5.1
Household Numbers (millions)	1.9	2.1	1.9	2.1
Emissions Price ($/t)	$25	$25	$50	$50
Exchange Rate (US$/NZ$)	0.60	0.60	0.60	0.60
Oil Price (US$/bbl real)	$89	$120	$97	$115
Gas Discoveries (PJ per annum)	100 PJ	100 PJ	110 PJ	122 PJ

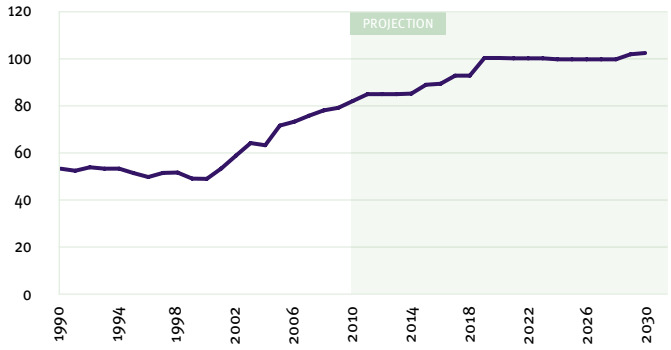
Energy Sector Greenhouse Gas Emissions

kt CO2-e



Wholesale Electricity Price Indicator (Real)

$/MWh



Consumer Energy Demand

Detailed Data Tables Available at:
www.med.govt.nz/energyoutlook

Reference Scenario

Consumer energy demand is energy that is used by final consumers. It excludes energy used for transformation (e.g. in the generation of electricity) and non-energy purposes (e.g. in the manufacturing of petrochemicals).

On a sector basis, consumer energy demand is dominated by transport and industry (e.g. dairy, wood processing, aluminium smelting), which collectively represent over 80% of the country's demand. Residential and commercial users account for the rest.

Consumer energy demand has been increasing at an average rate of 1.4% per annum since 1990. Demand from most sectors dropped through the recent recession and recovery period. Economic growth is expected to rebound, although the longer-term outlook is for lower than historical rates of population and economic growth, which, when combined with higher energy prices and ongoing energy efficiency gains, sees reduced long-term energy demand growth forecasts compared with historical rates. The *Reference Scenario* sees growth in consumer demand reduce to an average long-term growth rate of 0.9% per annum by 2030. Oil is expected to continue to dominate consumer demand in this *Reference Scenario*, reflecting our continued reliance on oil as a transport fuel.

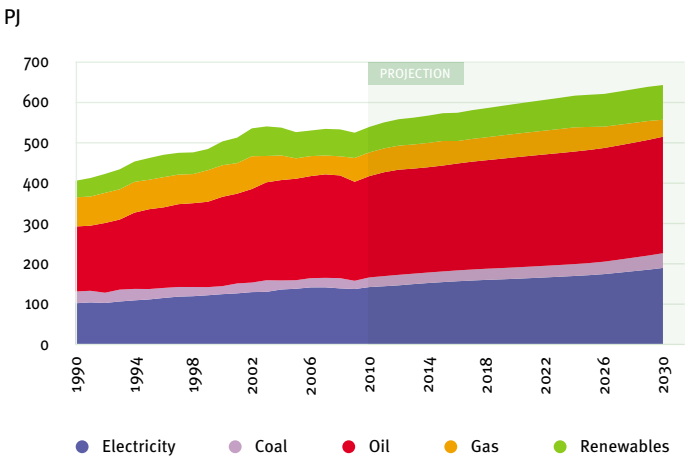
Around half of the energy used by New Zealand consumers is in the form of refined oil products (mostly petrol and diesel). Most of this is used for transport and in mobile off-road uses such as in the construction industry and on farms. Stationary uses such as in boilers and diesel generators make up a relatively small amount of diesel demand. New Zealand has a well developed oil production industry but for technical and economic reasons most of our crude oil is exported. Therefore nearly all of the oil used in New Zealand is imported.

The next largest source of consumer energy is electricity. This provides close to a quarter of total consumer energy, while the direct use of gas, coal, geothermal, wood and other renewables makes up the balance.

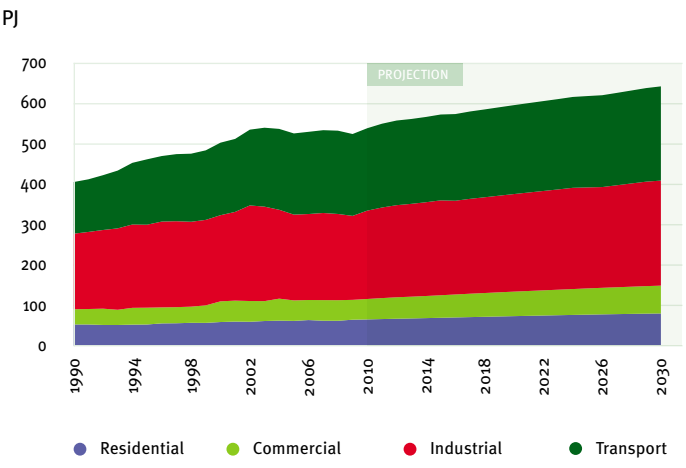
Transport energy demand continues to slow under the *Reference Scenario*. This reflects personal road travel reaching close to saturation levels after strong growth throughout the 1990's and early part of the last decade. During this time the light vehicle ownership rate in New Zealand increased to one of the highest in the world. In addition, there is considerable scope for efficiency improvements in New Zealand's light vehicle fleet. In Europe and Asia, vehicle manufacturers are now being strongly regulated to improve the efficiency of vehicles and New Zealand drivers should benefit as these more efficient vehicles are purchased and gradually replace the existing stock. In the *Reference Scenario* these factors reduce growth in oil demand from historical rates of 2.5% per annum to less than 1% per annum.

This year's *Energy Outlook* modelling includes domestic biofuel production and an uptake of electric vehicles in response to ongoing increases in oil prices. However, with only low rates of biofuel and electric vehicle uptake in the *Reference Scenario*, imported oil continues to dominate New Zealand's energy demand and remains a key challenge in terms of energy security and limiting our greenhouse gas emissions.

Consumer Energy Demand by Fuel Type



Consumer Energy Demand by Sector



Sub-sector Demand

Detailed Data Tables Available at:
www.med.govt.nz/energyoutlook

Reference Scenario

New Zealand's non-transport energy demand can be split into three broad sectors: industrial, commercial and residential, contributing 40%, 9% and 12% of total demand respectively.

The industrial sector includes both New Zealand's light industry (including agriculture and construction) and heavy industry (wood and dairy processing, steel making etc). Light industry groupings tend to include multiple participants each contributing a relatively small proportion of the sector's total energy demand. In contrast, the heavy industry sector includes a small number of large energy intensive plant. As a result, the heavy industry sector can see lumpy energy demand growth as new plant is built. In our *Reference Scenario*, we avoid making any assumptions about new plant but do incorporate any available information from the current participants or any reputable sector-specific forecasts.

In the *Reference Scenario*, energy demand for all of these sectors is projected to increase. Demand growth in the industrial and commercial sectors has been largely non-existent through the recent difficult economic times and once growth returns this is expected to be at lower rates than those observed historically.

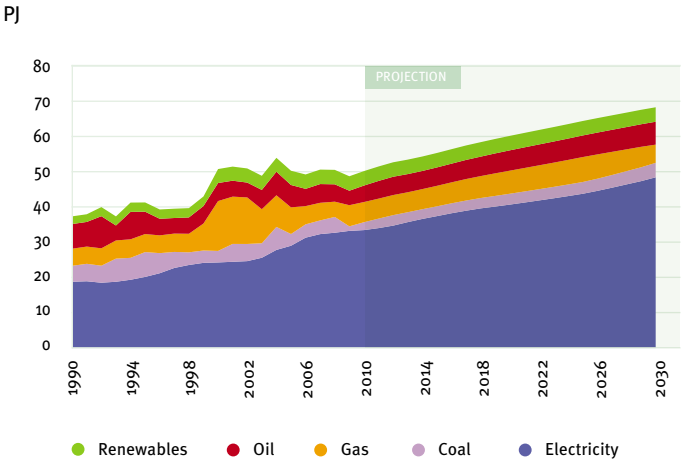
Electricity currently makes up the largest share of industrial sector energy demand at 27% of the total, followed by renewables at 25% (including biomass 21% and geothermal 4%), gas at 22% and coal at 9%. By 2030 in the *Reference Scenario*, gas makes up a lower proportion of industrial energy as methanol production is scaled back. Industrial plant often requires a heat source which is best provided by the on-site combustion of fuel rather than from electricity, so it is no surprise that our *Reference Scenario* continues to see the use of wood, coal and gas in this sector (25% wood, 12% coal and 12% gas in 2030).

The commercial sector covers wholesale and retail trade, telecommunications, financial institutions etc. Electricity dominates energy demand in the commercial sector at around 65% of the total. When compared with other fuels, electricity demand has also experienced the greatest growth in this sector over the previous two decades.

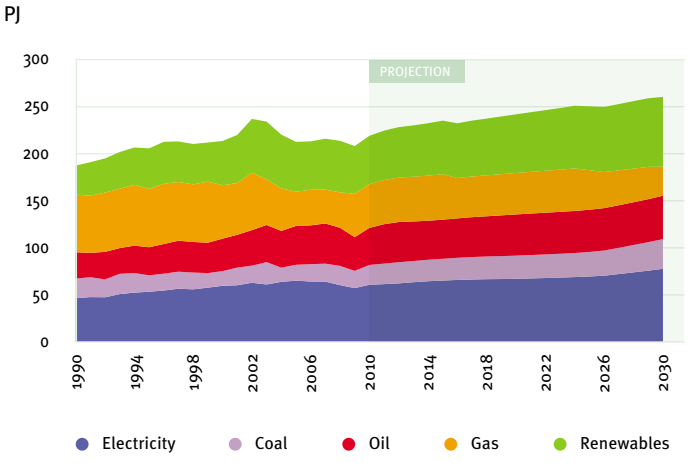
The residential sector covers households' use of energy but excludes transport, which is included under transport demand. Residential energy demand is dominated by electricity, which accounts for almost all of the growth in demand. Residential energy demand has been seen to be more resilient to the ups and downs of the economic cycle and continues to grow broadly in line with the growth in households. The *Reference Scenario* assumes that household efficiency gains will continue in line with levels seen in the past. As readers may be aware, there are already a number of government backed programmes operating which are aimed at improving household energy efficiency.

Note that significant revisions have been made to New Zealand's historical energy data that were published in the 2010 edition of the Energy Data File. Gas combusted at petrochemical plants is now included as part of the industrial sector energy demand as specified by the International Energy Agency guidelines. In addition, more reliable wood use data has become available which shows a rise in the energy sourced as biomass.

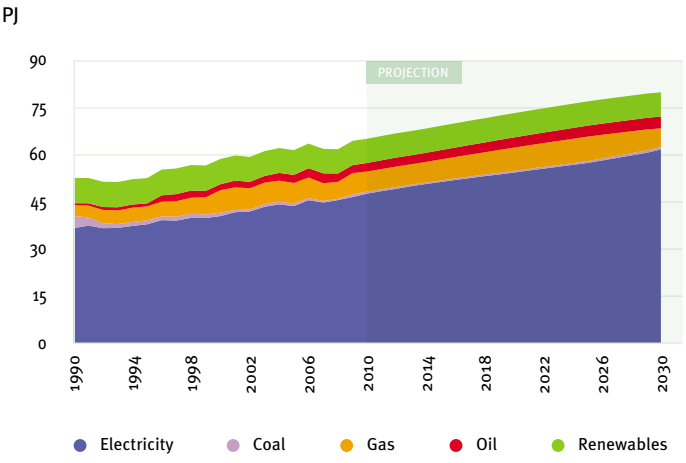
Commercial Demand by Fuel Type



Industrial Demand by Fuel Type



Residential Demand by Fuel Type



Electricity

Detailed Data Tables Available at:
www.med.govt.nz/energyoutlook

Reference Scenario

Demand for electricity has been growing at an average rate of 1.6% per annum since 1990, driven by GDP growth of 2.7% per annum and household numbers growing at 1.4% per annum.

In the *Reference Scenario*, demand growth is projected to slow slightly to 1.4% over the 2010 to 2030 period (growth in GDP and household numbers is assumed to reduce to 2.3% and 1.2% respectively).

Industrial electricity demand is projected to grow by 1.2% per annum, close to the historical rate of 1.1%. Energy use in this sector is strongly linked to economic activity. While the lower future GDP growth limits demand growth, this is offset by some switching from gas to electricity in the latter part of the forecast period.

Commercial demand has experienced some very high periods of growth in the past, concentrated in the "boom" economic years of the mid-1990's and early/mid-2000's. Historical average growth of 3% is projected to reduce to 1.9% but it still remains the fastest growing sector.

Historically, residential electricity demand has been growing at 1.3% per annum in line with the growth in household numbers. This rate is projected to remain at 1.3% with the demand reduction from lower population growth offset by some switching from gas to electricity. The impacts of government-led energy-efficiency programmes are implicitly included in these demand projections.

New Zealand's electricity supply is currently dominated by hydro generation, supported by gas, coal, geothermal and wind. Emissions pricing, gas supply, steel prices and exchange rates are the key factors which will determine how the mix of generation technologies will evolve in the future, and the resulting impact on electricity prices.

Emissions pricing is a substantial risk for coal plant, so we assume no new coal plant is built and the existing Huntly station is phased out over time. Development of renewable generation is less risky under this policy setting, so approximately 900MW of geothermal, 1,500MW of hydro, and 750MW of wind is built by 2030. Between 2030 and 2040 there is another 1,800MW of wind built since the model used assumes geothermal resource is exhausted and further hydro developments will be significantly more costly.

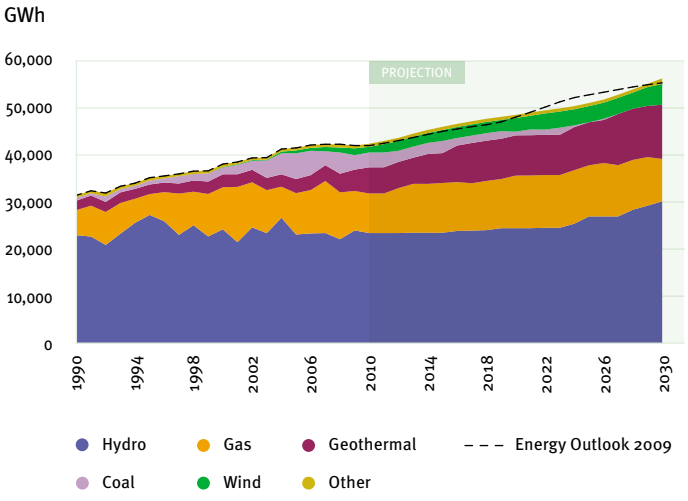
This *Reference Scenario* allows for higher gas production from new discoveries than in *Energy Outlook 2009*. Analysis of New Zealand's frontier petroleum basins suggests there are likely to be more gas discoveries in the future, although there is much uncertainty surrounding the timing and size of potential discoveries.

This uncertainty around gas supply limits investment in new baseload gas plant. Over the Outlook period, two existing baseload gas plant are decommissioned, but replaced by new plant, so there is no net increase in baseload gas capacity by 2030.

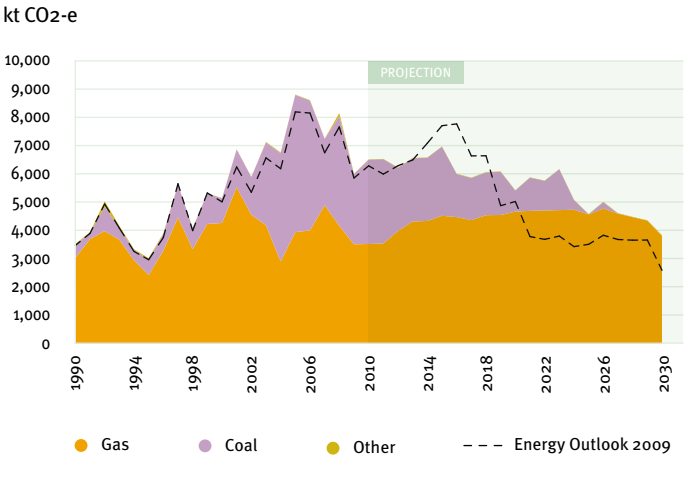
In the *Reference Scenario*, 460MW of new gas peakers and 380MW of diesel peakers are expected to be built by 2030. This investment in new peakers is significantly above that seen before and is driven to a large extent by the need to provide backup for wind generation, to replace the dry year backup role of the aging Huntly coal units, and to meet peak demand.

By 2030, electricity emissions return to close to 1990 levels. The Huntly coal units have all been completely decommissioned by 2030. The use of gas starts to decline from 2030 as Taranaki reserves become depleted and New Zealand has to rely on more expensive gas produced in frontier basins.

Electricity Generation by Fuel



Electricity Greenhouse Gas Emissions[1, 2]



[1] Emissions resulting from geothermal electricity generation are covered under fugitive emissions as these are the result of the extraction process.

[2] Historical greenhouse gas emissions have been revised due to some cogeneration now being assigned to electricity generation, instead of manufacturing.

Transport

Detailed Data Tables Available at:
www.med.govt.nz/energyoutlook

Reference Scenario

New Zealand's transport system is dominated by road transport and almost universally powered by the internal combustion engine and oil products. While sea and air transport are important transport modes, land transport accounts for over 90% of total transport energy demand.

In recent decades the wide availability of affordable vehicles, relatively cheap fuel, low fuel taxes and limited public transport networks outside the main centres have seen New Zealand develop one of the world's highest per capita car ownership rates. In turn, this easy access to vehicular transport, along with strong economic and associated freight growth, has seen total transport demand increase by almost 60% since 1990 – a rate of around 2.5% per annum.

Since 2004, things have changed quite dramatically. Transport demand growth has slowed to just 0.8% p.a. with demand for petrol actually declining by 3%. Factors influencing this change include the sharp oil price rise in 2008, the subdued economic climate following the 2008 recession and improvement in the fuel economy of vehicles entering the fleet from Europe and Asia.

The *Reference Scenario* sees higher future fuel prices[3] and in response we assume that by 2030 new light vehicles[4] entering the fleet will be 11% more efficient. These trends, along with some migration to light diesel vehicles, see New Zealand having hit peak petrol demand with no further growth in petrol demand expected in the *Reference Scenario*.

Central GDP forecasts are that the economy will return to growth from 2010 and that increased economic activity will see increased freight movement and diesel demand.

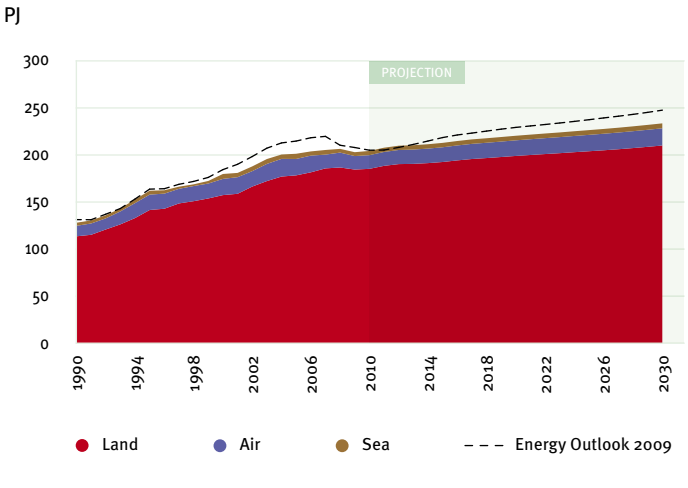
In the longer term, electric vehicles are expected to feature in the vehicle fleet. The rate of uptake of electric vehicles will depend on the market's acceptance of them and on their price. Higher rates of production will greatly reduce the costs of battery and components but here we assume that the vehicles remain at a price premium compared with internal combustion vehicles.

The *Reference Scenario* sees sales of full electric (EV) and plug-in hybrid (PHEV) vehicles growing to a market share of 10% of all new light vehicles sold in 2030. In that year, electric vehicles will travel approximately 4% of total vehicle kilometres but consume less than 1% of the road transport energy demand. New Zealand has already seen a few of these vehicles, which are being leased as part of a number of pilot projects, and indications are that vehicles will be offered onto the market for sale from 2012.

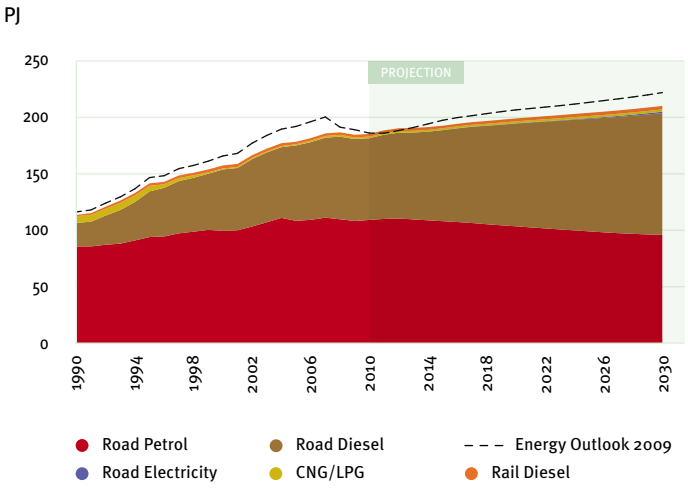
This *Reference Scenario* also sees an uptake of biofuels in New Zealand. Small quantities of ethanol and biodiesel are already produced and sold in New Zealand using "first generation" technology. These "first generation" biofuels have a number of inherent limitations and greater hope is seen in the development of "second generation" biofuels, where biomass from a range of non-food crops is used along with more efficient transformation pathways.

The uptake of second generation biofuel technologies will involve large industrial-scale investments and the associated business risk, including the perils of competing with a variable price of oil. In this *Reference Scenario* biofuels become economic from 2030, when the landed price of diesel is expected to be above $1.50/litre (in 2010 dollars). It is worth noting that other alternative transport fuels not included in the *Reference Scenario* may also be economic at such prices. These fuels include liquid or gaseous fuels derived from lignite and hydrogen combined with fuel cell vehicles. All the alternatives have a range of benefits and issues to overcome including technological, environmental and economic.

Transport Demand by Mode



Land Transport Demand by Fuel Type



[3] The *Reference Scenario*'s long-term oil price projection is based on the International Energy Agency's World *Energy Outlook 2009*, which is US$115 per barrel by 2030. This translates to a petrol pump price of $2.70 per litre (in 2010 dollars).

[4] Light vehicles are passenger vehicles with no more than nine seating positions, or a goods vehicle that has a gross vehicle mass not exceeding 3.5 tonnes.

Sensitivity Analysis

A country's energy consumption and the level of economic activity are closely linked. This relationship has been borne out over many years. For example, the strong economic growth in New Zealand in the decade from the mid-1990's was coupled with strong growth in energy consumption. Conversely, the recent economic downturn has seen a flattening of growth in energy consumption.

In the *Reference Scenario*, assumptions regarding future GDP growth rates are taken from the Treasury's BEFU[5], which is for levels close to 3% in the near term trending down to levels between 2% and 1.8% from 2020 to 2030. At the same time, our population growth is expected to reduce to around 0.5% per annum in the 2030's giving GDP per capita growth at around 1.5% per annum in the long term. This rate is in line with the long-term productivity improvements seen in our economy.

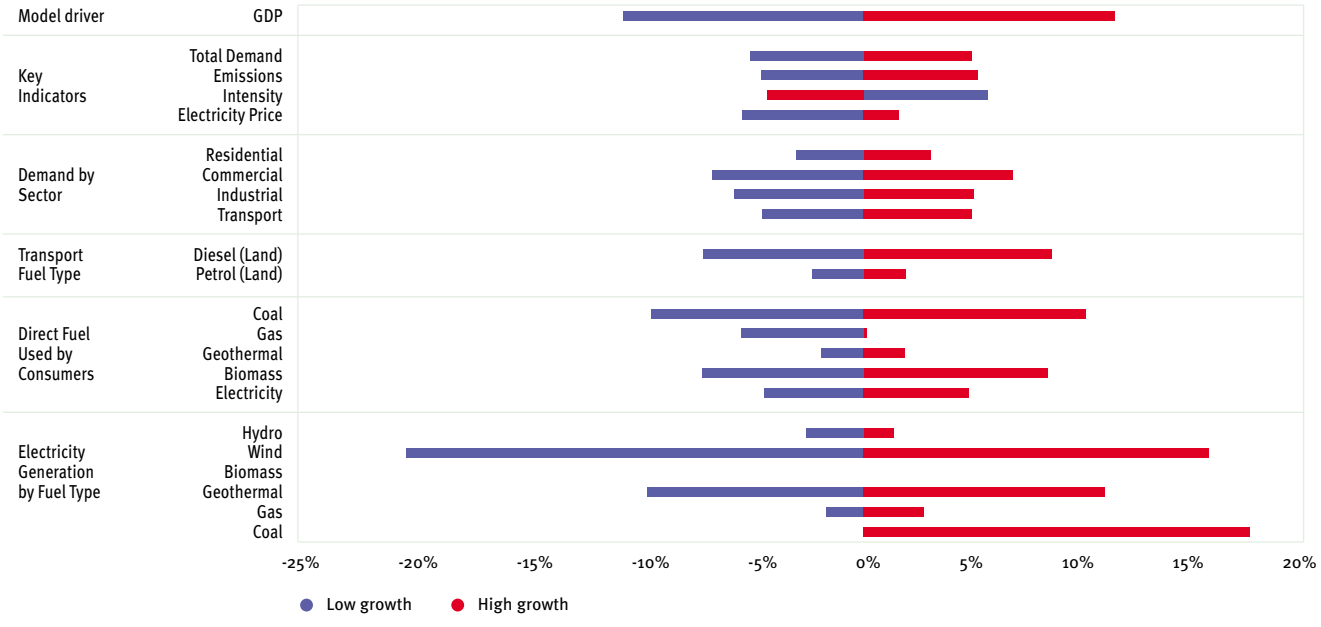
In the high growth sensitivity case, we examine the sensitivity of our *Reference Scenario* to GDP growth that is 1% per annum higher than the central forecast with long-term average growth of almost 2.8% per annum. By 2030, GDP in this sensitivity case is almost 22% higher than the central forecast. It is also assumed that there is higher growth in residential house numbers.

In the low growth sensitivity case, GDP growth is modelled at 1% per annum below the central forecast, producing a long-term average of just 0.5% per annum. By 2030, GDP in this sensitivity case is almost 19% lower than the central forecast. As in the higher growth case, household numbers have been adjusted to reflect the corresponding change in economic growth.

Highlights

- In the high growth case, energy intensity improves at a rate of 1.6% per annum reflecting a greater uptake of energy efficient technology, and further growth in less energy-intensive sectors of the economy. In the low growth case, energy intensity improvements reduce to a rate of 0.7% per annum lower than the *Reference Scenario*'s 1.3%.
- Industrial and commercial energy demand growth is correlated with GDP, while residential energy demand is affected more directly by population and household numbers.
- With little additional gas available in the high growth case, the increased consumer demand is shared between electricity, coal and biomass.
- Diesel demand has a stronger relationship with GDP than petrol. This reflects the many commercial uses made of diesel such as in trucks carrying freight and off-road in agriculture and construction.
- Electricity prices increase only slightly in the high growth case. This is because the wholesale electricity price in the *Reference Scenario* is already at a level to support the additional investment in new generation required.
- Wind generation capacity is heavily influenced by electricity demand, and therefore GDP. New Zealand has a large number of identified potential wind farm sites and with the economics sitting somewhere between geothermal and hydro it is likely that wind will provide a substantial proportion of the new generation required to 2030.
- Coal use for electricity generation increases in the medium term in the high growth case with Huntly operating at a greater capacity factor to provide a share of the additional demand.
- In the low growth case, electricity prices are over 5% lower than in the *Reference Scenario*, reflecting lower electricity demand and the consequent reduced need for more expensive new generation capacity.

Average % Change from the Reference Scenario, 2013 to 2030



[5] BEFU – Budget Economic and Fiscal Update www.treasury.govt.nz/budget/forecasts/befu2010

Sensitivity Analysis

In the years since 1990, increased consumption of petrol and diesel has been the major source of growth in New Zealand's energy demand and associated greenhouse gas emissions. Oil currently provides over half of New Zealand's consumer energy demand, and almost 98% of our transport fuel.

Given oil's central role in the economy, changes in the international price of oil can have a material impact on the energy sector and broader economy. The price elasticity of demand for oil products is very low and because oil is such a widely used and internationally traded fuel, its price influences the price of other energy types. In fact the oil price is often used as a price marker in fuel supply contracts (LNG is an example).

In the oil price sensitivity cases it is assumed that price elasticity relationships observed at historical prices hold at the new price levels tested. In actuality we cannot be sure of this at price levels beyond those seen historically.

Changes to the oil price also affect the economics of oil exploration and production. As gas production is generally associated with oil production, it can be expected that any increased return on oil production would also see local gas production rise.

The *Reference Scenario*'s oil price projection is based, in the short term, on the New York Mercantile Exchange (NYMEX) oil futures market and, in the longer term, on the prices modelled in the International Energy Agency's *World Energy Outlook 2009 Reference Scenario*.[6] In this scenario, real oil prices rise steadily to US$115 per barrel (bbl) by 2030 (in real terms).

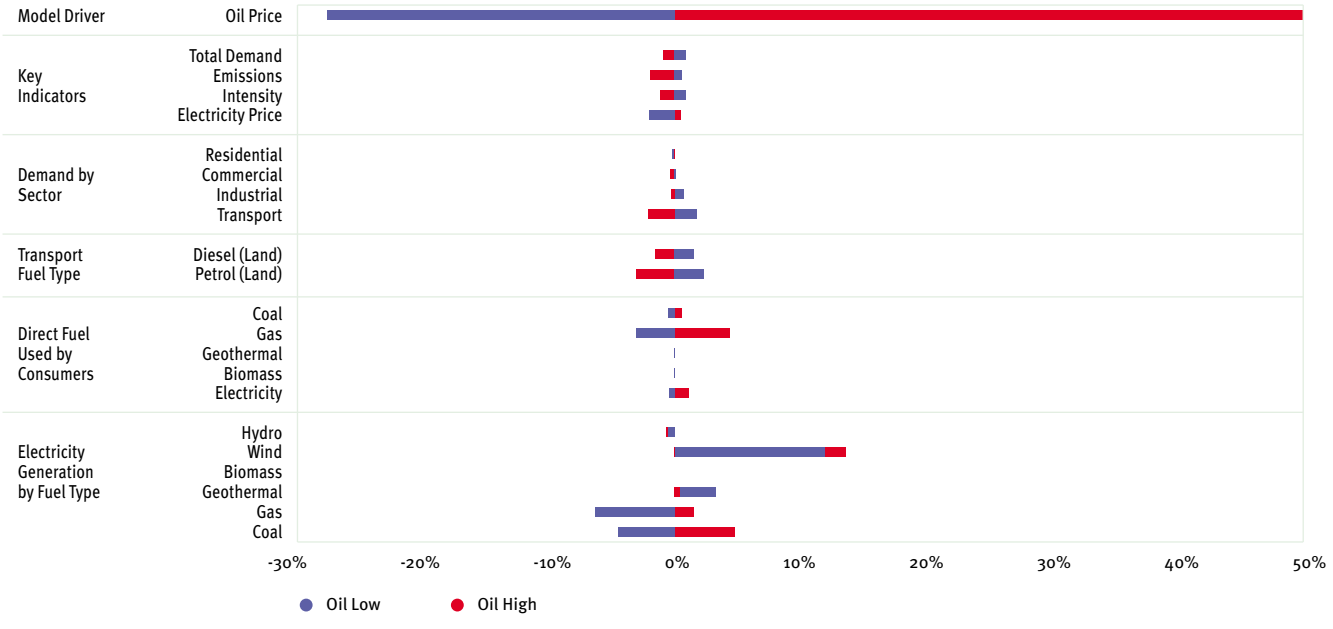
In the high oil price sensitivity case, international crude oil prices are higher than the *Reference Scenario* and reach US$172/bbl by 2030 in real terms. This equates to pump prices of around $3.50 and $3 per litre for petrol and diesel respectively. In the low price sensitivity case, crude oil prices are assumed to remain at US$70/bbl in real terms.

At the higher fuel prices, our modelling sees increased popularity of smaller and more fuel-efficient light vehicles. In the high oil price case, the share of electric vehicles in new vehicle purchases grows to 14% by 2030. Similarly, the higher oil prices bring forward the point where second generation biofuels become economic and by 2030 they provide more than 200 million litres of fuel. This is only a small proportion of our total fuel demand, reflecting the business risks of an emerging technology competing with the future oil price.

Highlights

- Oil remains New Zealand's dominant energy source even at oil prices above US$170 /bbl.
- A 50% increase in the international oil price increases the retail price of petrol and diesel by 29% and 39% respectively. However, these price rises are expected to see a decrease in transport energy demand of only 2.5%.
- Higher oil prices see an increased uptake of more efficient light vehicles, battery electric vehicles and plug-in hybrid electric vehicles.
- At higher oil prices, alternative fuels become economic but their level of uptake is limited by the inherent business investment risks of competing with future unknown oil prices.
- High oil prices improve the economics of oil and gas field development and this leads to increased gas supply in the 2020's.
- In the low oil price case, reduced supply of gas limits gas-fired electricity generation, and wind generation increases by 12%.

Average % Change from the Reference Scenario, 2013 to 2030



[6] www.worldenergyoutlook.org

Exchange Rate

Detailed Data Tables Available at:
www.med.govt.nz/energyoutlook

Sensitivity Analysis

New Zealand and its transport system are heavily reliant on imported oil, from which we refine the fuels that power our vehicles, aeroplanes and ships. The price faced by New Zealand consumers for these fuels depends on the international oil price, local taxes and margins and the exchange rate. In addition, virtually all of our motor vehicles are manufactured abroad and the exchange rate influences our ability to afford the latest vehicle technology.

Similarly, much of the energy infrastructure deployed in New Zealand is imported. Electricity turbines and control components are typically manufactured in Europe, Japan or the US with their delivered price fluctuating with the exchange rate. For this reason investment decisions in these technologies are heavily influenced by the exchange rate.

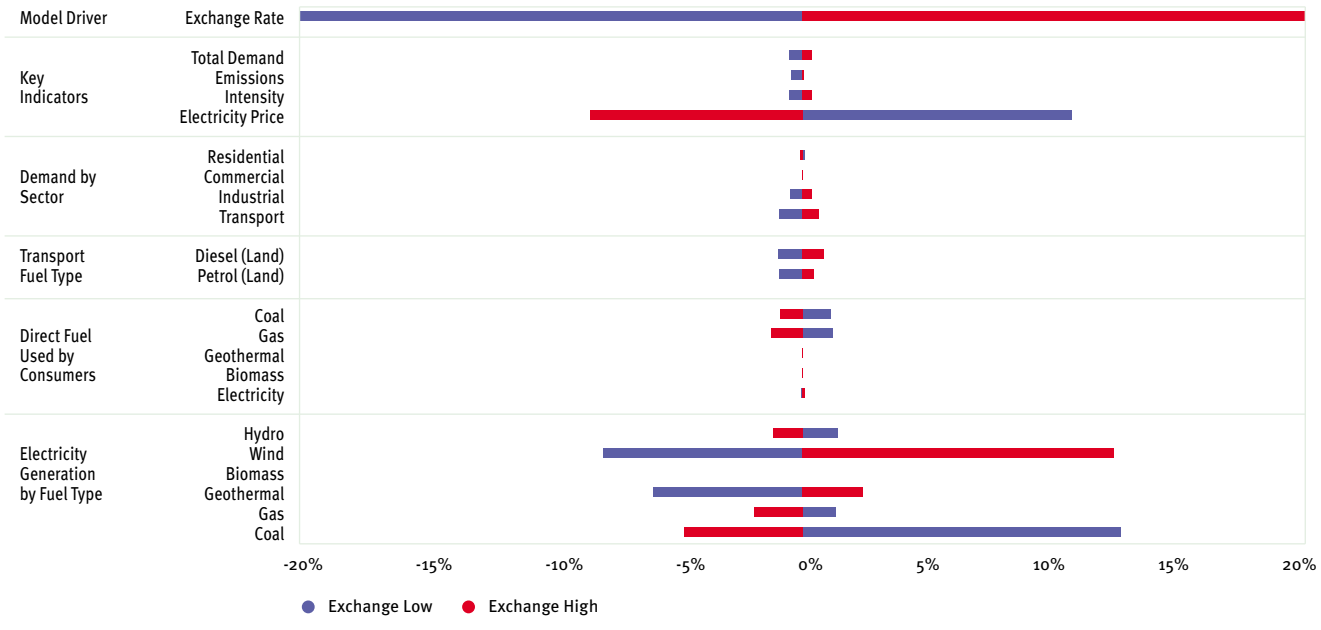
The purpose of this sensitivity analysis is to show the impact of exchange rates on demand for imported oil, its influence on the capital costs of new electricity generation and the effect this has on new generation investment.

In the *Reference Scenario*, exchange rates to 2013 are based on the Treasury's updated mid-term forecast,[7] then trend towards the long-run average rate of close to 0.6 US$/NZ$. The high exchange sensitivity case sees the New Zealand dollar appreciate in value by 20%, reducing the cost of imported fuels and equipment. In the low exchange sensitivity case, the New Zealand dollar depreciates by 20%, which increases the costs of imports.

Highlights

- The exchange rate has a large direct effect on the price of petrol and diesel. However, low price elasticities of demand mean these price increases have little impact on demand.
- A higher exchange rate lowers the costs of imported vehicles, enabling a quicker uptake of electric vehicles. However, a high exchange rate will also lower the price of oil products, which hinders the economics of domestically produced biofuels.
- Appreciation of the exchange rate improves the economics of new electricity generation due to the large proportion of imported components making up the total capital costs. In the high exchange rate case, the long run marginal cost (LRMC) falls for all technologies:
  - The LRMC for geothermal and wind is reduced by around 10% compared with the *Reference Scenario*.
  - As hydro stations tend to have more local costs than wind or geothermal, LRMC drops by about 7%.
  - Gas stations have a much lower capital cost component and much higher variable cost component so the LRMC drops by less than 5%.
- With a higher exchange rate, the impact of these changes in the costs of new generation results in greater investment in wind and geothermal capacity. In turn, this scenario sees a corresponding drop in the use of gas, coal and hydro for electricity generation relative to the *Reference Scenario*.
- In the low exchange rate case, we see more generation from coal and gas with reduction in wind and geothermal generation due to the relatively higher costs of these generation types.
- As the high exchange rate reduces the cost of new generation investment overall, wholesale electricity prices are around 8% lower than in the *Reference Scenario*. Conversely, in the low exchange case electricity prices are 10% higher.

Average % Change from the Reference Scenario, 2013 to 2030



[7] BEFU – Budget Economic and Fiscal Update www.treasury.govt.nz/budget/forecasts/befu2010

Emissions Price

Detailed Data Tables Available at:
www.med.govt.nz/energyoutlook

Sensitivity Analysis

In New Zealand an emissions trading scheme (ETS) has introduced an emissions price on fossil fuels. Energy consumers are expected to respond to higher fossil fuel costs by reducing their consumption, improving energy efficiency or by switching to alternative low emissions fuels – or more likely a combination of all three. Energy producers will be encouraged to identify less emissions-intensive energy sources. This section explores the implications of various levels of emissions price.

The *Reference Scenario* assumes an emissions price of $50 per tonne of carbon dioxide equivalent (CO_2-e) emitted from 2013. This is the standard price for all analysis by the Treasury of the New Zealand ETS post 2013. Four alternative sensitivities are considered:

a. No emissions price.
b. $25/t emissions price.
c. $75/t emissions price.
d. $100/t emissions price.

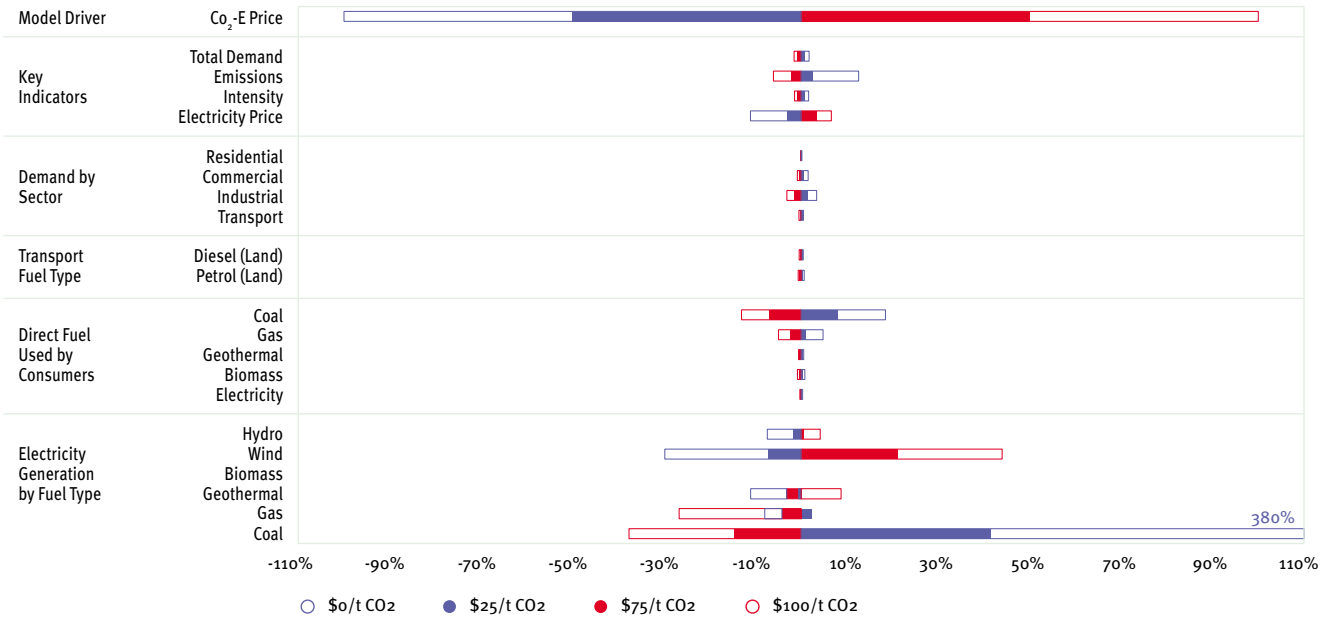
In each case, we assume an equivalent cost is faced by the majority of the international community, including New Zealand's major trading partners. This in turn allows us to assume that the imposition of emissions pricing in New Zealand will not directly result in structural change to the economy (through "leakage" of particular sectors overseas). However, we have assumed that heavy industry in New Zealand as a whole becomes more energy-efficient in response to emissions pricing. We have also assumed that the increased costs faced by New Zealand's heavy industry as a result of emissions pricing will be phased in over a long period as ensured by the industry support provided under the revised ETS.

The "no emissions price case" contains no limitations on emissions-intensive activities. The key implication is that it allows investment in new coal-fired electricity generation. For the other sensitivities, it has been assumed that the existence of an emissions price and associated commitment to reducing emissions make investment in new coal-fired generation a risky proposition, and is therefore excluded from the analysis.

Highlights:

- Emissions prices above the *Reference Scenario* level of $50/tonne have only limited further impact on emissions. For example, doubling the price from $50/tonne to $100/tonne reduces energy sector emissions by 6%.
- Introduction of emissions pricing has a substantial impact in the electricity market, affecting both new generation investment and wholesale electricity prices.
- In the no emissions price sensitivity case, coal-fired electricity generation rises by nearly 400% with 1,200MW of new coal or lignite plant built by 2030. This increase in cheap coal-fired generation sees the wholesale electricity price reduce by over 10% compared with the *Reference Scenario*.
- The impact of different emissions prices on petrol and diesel demand is minor due to the relative insensitivity of consumption to price. Even at $100/tonne, and an associated increase in fuel costs of 27 cents per litre, petrol and diesel demand is just 0.7% and 0.4% less than the *Reference Scenario* in 2030.
- Emissions pricing will increase the price of petrol and diesel and encourage the uptake of alternatives such as electric vehicles and biofuels. However, the increases in price are small and do not trigger much additional uptake of these alternatives.
- Total consumer energy demand reduces as emission prices rise with low carbon electricity and biomass growing their shares at the expense of coal and gas.

Average % Change from the Reference Scenario, 2013 to 2030



The information included in this article is based on an integrated approach, combining modelling from the Supply and Demand Energy Model (SADEM), Generation Expansion Model (GEM) and the Vehicle Fleet Model (VFM).

Reference Scenario

Like most economic and engineering modelling techniques, the complex supply and demand dynamics within New Zealand's energy sector can be broken down into a series of mathematical relationships based on observations of past behaviour, key macroeconomic drivers and engineering estimates. This is supplemented by information supplied by market participants.

While models are useful tools to help inform our understanding about the relationships between different variables, there are inherent limitations that need to be borne in mind when interpreting results. In particular, the future is uncertain and cannot take into account the subtleties of commercial decision-making or barriers to investment. Such models also consider only a sub-set of the economy so second order impacts are ignored.

Reference Scenario

- GDP growth follows the projections produced by the Treasury; in the short term, from the Budget Economic and Fiscal Update (BEFU) 2009, and in the longer term, from the Long Term Fiscal Model where rates trend down towards the long-run labour productivity rate of 1.5%.
- Exchange rates to 2013 are also based on the Treasury's updated forecast. For the period 2014 to 2020, exchange rates trend towards the long-term rate of 0.60 US$/NZ$ and remain at this rate indefinitely.
- Oil prices are assumed to follow the New York Mercantile Exchange (NYMEX) futures price in the near term, trending towards the International Energy Agency's *World Energy Outlook 2009* mid-case projection of US$115/bbl (real) by 2030.
- An emissions price of $50 per tonne of carbon dioxide is assumed from 2013. The price reflects the expectation of a more stringent post-Kyoto target in line with New Zealand's emissions reduction target range of 10% to 20% below 1990 levels by 2020.
- Future gas discoveries, the commercial viability of development and the resulting "break-even" gas prices are modelled. A separate methodology document explains this modelling in more detail. The result is an average of around 120 PJ per annum of new gas production between 2017 and 2030.
- Gas prices are based on the intersection of total gas demand and the supply curve (derived using the above gas discovery model). Prices remain flat until 2030.
- Heavy industry is assumed to be slowly exposed to emissions pricing over a period of 15 years and responds through improved energy efficiency. No assumptions around industry expansion or closure as a result of emissions pricing have been made.
- Two units at Huntly coal fired power station are switched to dry year reserve in 2012 and 2016 respectively. The remaining two units are decommissioned in 2020 and 2024. No further coal stations are built.
- The existing baseload gas plant at Stratford and Otahuhu are decommissioned in 2025 and 2030 respectively.
- The light vehicle fleet grows from 680 to a saturation level of 720 vehicles per 1,000 people.
- Purchases of light diesel vehicles grow to 25% of new light vehicles by 2015.
- Purchases of electric vehicles grow to 10% of all new light vehicles by 2030.

Sensitivity Analysis

Sensitivity Analysis

GDP

I Low growth - 1% per annum below the central GDP forecast.
II High growth - 1% per annum above the central GDP forecast.

Oil Price

III Low oil prices - flat US$70/bbl in real terms.
IV High oil prices - 50% higher than the Reference Scenario, reaching US$172/bbl by 2030, in real terms.

Emissions Price

V No emissions price.
VI $25/t emissions price.
VII $75/t emissions price.
VIII $100/t emissions price.

For every $25/t increase in the emissions price in the sensitivity cases, the assumed decommissioning dates for units at Huntly coal and Stratford and Otahuhu gas plant have been brought forward by one year.

Exchange Rate

IX Low exchange rate case - 20% reduction in the central Exchange Rate forecast.
X High exchange rate case - 20% increase in the central Exchange Rate forecast.

The exchange rate sensitivity cases show the direct impact of exchange rate on the cost of imported oil and its influence on capital costs for new electricity generation. No feedback loops with GDP have been considered, nor have the impact of higher exchange rates on New Zealand's export sectors.

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