New Zealand's Energy Outlook 2011

Reference Scenario and Sensitivity Analysis

Welcome

New Zealand's Energy Outlook 2011 presents updated projections of New Zealand's future energy supply, demand, prices and greenhouse gas emissions. These projections are intended to inform the energy debate.

This article updates the analysis presented in the *Energy Outlook 2010*, incorporating new and revised energy data as well as updated modelling assumptions and methods.

The *Reference Scenario* provides a benchmark for comparisons in the *Sensitivity Analysis*. The *Reference Scenario* is not our expectation of what is going to happen. Rather, it assumes a continuation of the broad trends of key economic drivers and policy settings, as well as current technologies and fuel choices. The *Reference Scenario* assumes the continuation of enacted government policies, such as the emissions trading scheme. Detailed assumptions are discussed at the end of this article.

The *Sensitivity Analysis*, the second part of this article, 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 website and a technical reference document that details the methodology used.

Transport modelling for the *Energy Outlook 2011* was a joint exercise between the Ministry of Economic Development and the Ministry of Transport.

Key messages from the Reference Scenario and Sensitivity Analysis

Reference Scenario

- New Zealand's energy intensity improves 21% by 2030.
- In 2030, renewable energy sources provide around 50% of New Zealand's primary energy supply.
- Consumer energy demand is projected to grow at around 1% per annum over the next decade, lower than the 1.4% p.a. seen from 1990.
- Transport remains reliant on oil. Electric vehicles and biofuels remain minor players, contributing less than 2% of total transport energy demand in 2030.
- Energy sector emissions stabilise but remain around 40% above 1990 levels out to 2030.
- Electricity demand increases more than 25% by 2030, but associated emissions are 7% lower than in 2010. Investment in new generation is dominated by geothermal and wind.
- Emissions from transport continue to grow but at a much slower rate than in the past.
- Wholesale electricity prices may need to increase around 1% above the rate of inflation out to 2030 in order to support investment in new electricity generation.

Sensitivity Analysis

- By 2030 the high economic growth sensitivity case sees energy intensity fall to just over half that of 1990.
- High oil prices improve the economics of oil and gas field development and this leads to increased gas supply in the 2020s.
- Sustained higher oil prices encourage the purchase of more fuel-efficient vehicles and a greater uptake of electric vehicles and locally produced biofuels.
- Emissions in 2030 are more than 50% higher than 1990 levels in the high economic growth case.
- Emissions pricing of $100 per tonne CO_2-e reduces coal fired electricity generation but total energy emissions are only marginally lower than in the Reference Scenario (with $25 per tonne CO_2-e).
- 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/sectors-industries/energy/energy-modelling

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Ministry of Economic Development
Manatū Ōhanga

Reference Scenario

Energy intensity is a measure of energy used per unit of gross domestic product (GDP). It is influenced by both the composition of industry within an economy and improvements in energy efficiency.

Since 1990, New Zealand's GDP has increased at a much faster rate than consumer energy demand. This is shown by a reduction of over 21% in the amount of energy it takes to produce each unit of GDP over this period. This decrease in energy intensity is a result of energy efficiency and conservation measures (aided by advances in technology), and structural changes in the economy. In recent years, a growing proportion of the economy has been in the less energy-intensive service-based sectors. The GDP contribution by the trade, hospitality and commercial services sectors has nearly doubled since 1990, whereas the energy intensive manufacturing sector's GDP contribution has only increased by 20%.

Without improvements in energy intensity, energy demand would now be much higher. New Zealand's energy intensity peaked at over 5 GJ per $1000 of GDP* in the early 1990s. In 2010 New Zealand's energy intensity was less than 4GJ per $1,000 of GDP* and in the *Reference Scenario* energy intensity improves by a further 21% to around 3GJ per $1000 of GDP* by 2030. Over this time economic growth is forecast to average 2% per annum, with growth focused on the less-energy-intensive commercial sector. At the same time consumer energy demand grows at less than 1% per annum. The resulting improvement in energy intensity is aided by the uptake of new and more efficient technology in households, businesses, public services, and transport. Higher energy costs are also expected to increase the range of economic energy saving options. Recent high fuel prices and overseas trends towards efficient light vehicles appear to be influencing New Zealand's vehicle choices.

Around half of the reduction in energy intensity in the *Reference Scenario* occurs as growth in transport demand slows. Historical travel data indicates that personal road travel is already near saturation, with little additional per capita travel likely. This results in future personal travel demand growing in line with growth in the population at around 1% per annum to 2030 and well below GDP growth. In addition we expect light fleet efficiency improvements of close to 20% over this time. In the heavy fleet, vehicle efficiency remains relatively constant and so its energy demand increases as road freight increases, in line with economic growth.

Primary fossil fuel supply[1] provides an indication of how reliant a country is on fossil fuels. According to the International Energy Agency the proportion of fossil fuels within New Zealand's total primary energy supply is one of the lowest in the OECD. Only Iceland has a significantly lower share of fossil fuels in their primary energy supply. Like New Zealand, Iceland has a largely renewable electricity supply.

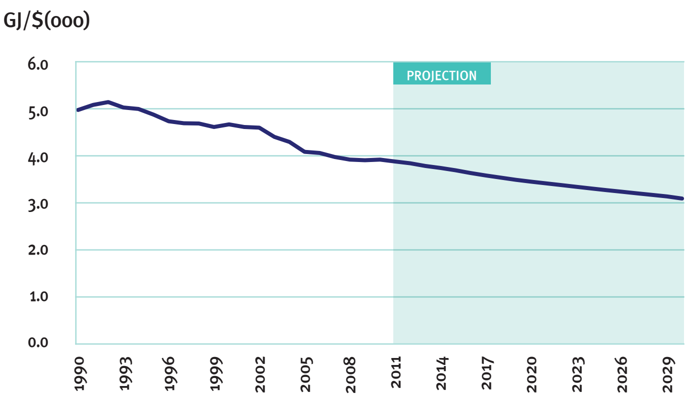
New Zealand's fossil fuel supply experienced strong growth until it peaked in 2001. This was driven by growing oil demand for transport and high gas demand for methanol and electricity production. In the early 2000s gas demand (particularly for methanol production) decreased as a result of a significant reduction in total gas supply and higher gas prices. More recently, primary fossil fuel supply has remained steady, with an increase in renewable electricity generation and weak economic growth.

Looking ahead to 2030, total fossil fuel supply remains relatively flat in the *Reference Scenario*. Oil demand for transport continues to grow, which is countered by a move away from coal-fired electricity generation. In the late 2020s industrial gas use decreases as gas prices rise with the development of oil and gas fields in new regions. In 2030, renewable energy sources provide over 50% of New Zealand's total primary energy supply.

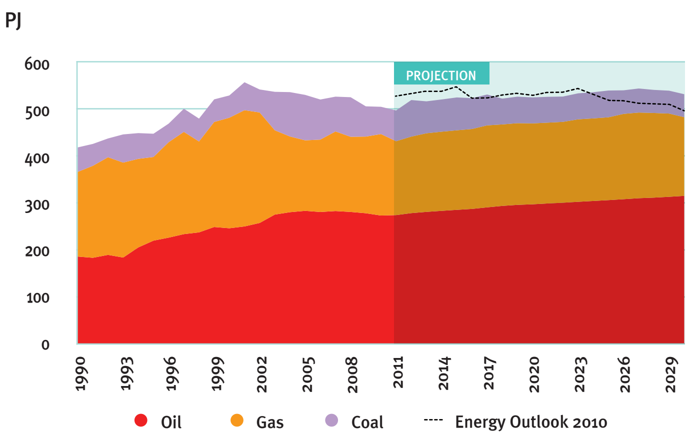
Primary fossil fuel supply in *Energy Outlook 2011* is lower in the short term than in *Energy Outlook 2010*, mainly due to revised input data and changes to the energy demand forecast models[2]. Out past 2025 demand is higher than previously forecast, as revised gas supply assumptions mean methanol production can continue for longer.

* Statistics New Zealand Chain-Volume Series 95/96 Price – Gross Domestic Product by Industry.

Consumer Energy Intensity – Reference Scenario



Primary Fossil Fuel Supply by Fuel Type



1 Fossils fuels supplied for use in New Zealand. This includes energy supplied for transformation purposes, non-energy use, and consumer energy demand.

2 A technical report "Review of MED's Demand Forecasting Methodology" is available on the MED website alongside the *Energy Outlook 2011*.

Reference Scenario

Energy sector greenhouse gas emissions in 2010 were 33% higher than in 1990 as a result of strong growth in transport demand and more electricity generation from coal and gas. Most of the growth in emissions was seen from 1990 to 2005, driven by increased transport energy demand and increased thermal electricity generation.

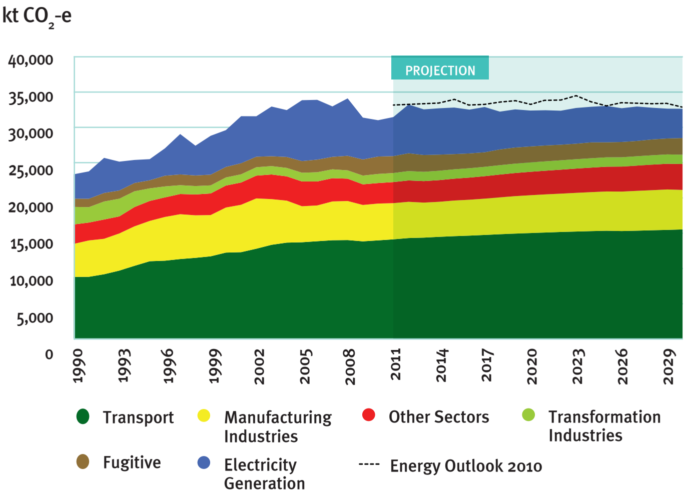
In the electricity sector, the *Reference Scenario* shows the contribution of renewables steadily increasing over the next two decades. Over this period electricity emissions reduce by 7% from 2010 levels, despite a 25% increase in demand. New Zealand benefits from a range of economic renewable technologies such as geothermal, wind and hydro, which meet future demand growth and displace the existing coal generation units at Huntly. The *Reference Scenario* assumes an emissions price of NZ$25 per tonne of carbon dioxide equivalent (CO_2-e) and assumes also that there is sufficient gas available to sustain a continued role for baseload and peak gas generation.

For most of the forecast period, emissions from manufacturing industries increase slowly. However, in the late 2020s gas supplies tighten, causing prices to rise, so we assume methanol production ceases. As a result, manufacturing sector emissions are forecast to be near current levels in 2030. Emissions from transformation industries and other sectors are projected to grow, albeit at lower than historical rates. Note that the *Reference Scenario* assumes an emissions price of NZ$25 per tonne of carbon dioxide equivalent (CO_2-e).

Transport remains the key challenge in New Zealand's bid to reduce energy sector greenhouse gas emissions. As emissions from other sectors remain flat or decline, transport increases its share of total emissions to nearly 50% by 2030.

In total, energy sector emissions remain flat in the *Reference Scenario* and slightly below the emissions forecast in *Energy Outlook 2010*. Forecast manufacturing sector emissions are generally lower due to revised input data and changes to the energy demand forecast model[2]. The larger difference (compared to *Energy Outlook 2010*) from around 2018 to 2025 can be explained by changes to the thermal electricity generation forecast. See page 6 for details.

Energy Sector Greenhouse Gas Emissions



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.

The wholesale electricity price indicator shows the direction of future prices if investors are to earn an economic return on new generation investment. The capital costs for building new electricity plants in the *Reference Scenario* are based on a recent report by PB Power[3], which sees costs increasing for all technologies.

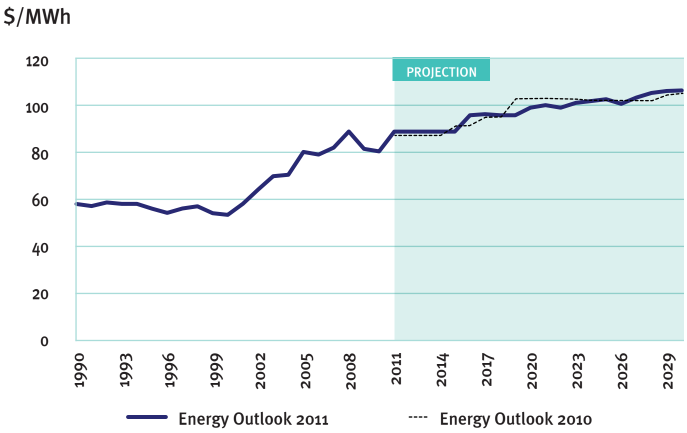
A common measure used to compare the economics of alternative generation projects is the long-run marginal cost (LRMC). In the *Reference Scenario*, geothermal tends to have the lowest LRMC, with most of the potential geothermal projects in the PB Power report below $90 per megawatt-hour (MWh). A number of wind projects have an LRMC of $90 to $110 per MWh, and a baseload gas plant has an LRMC of around $110 per MWh. A small number of hydro projects have an LRMC of less than $100 per MWh, but most are significantly higher than this.

The costs of building wind and geothermal projects are highly dependent on steel prices and exchange rates, and these have been relatively favourable over the last few years. The level of gas capacity built or maintained will not only be impacted by the availability of long-term gas contracts, but also by the relative costs of wind and geothermal and the availability of potential geothermal sites. Uncertainty surrounds many of these factors, with the *Reference Scenario* reflecting a balanced view across a wide range of outcomes.

The wholesale price indicator in the *Reference Scenario* is relatively flat for the next few years, with geothermal and some higher quality wind projects economic at current wholesale price levels. By 2020 wholesale electricity prices may need to rise to around $100 per MWh to continue to support new investment.

The *Reference Scenario* has nearly 850 MW of geothermal capacity built by 2030, with a further 750 MW available to be built in subsequent years. If further geothermal resources could be developed prior to 2030 then this would have a beneficial impact on the wholesale price indicator. Furthermore, if existing thermal generation is displaced there could be a beneficial impact on emissions. The Ministry is intending to do further work considering the size of New Zealand's geothermal resource for electricity generation.

Wholesale Electricity Price Indicator (Real)



[3] The PB Power report "2011 NZ Generation Data Update" can be found on the MED website alongside the *Energy Outlook 2011*.

Reference Scenario

Consumer energy demand is energy 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).

Almost 40% of consumer energy is used for transport. Another 40% is used by industry, including primary industries, manufacturing, and construction. Residential and commercial demand accounts for the rest.

Refined oil products such as petrol and diesel make up nearly half of New Zealand's consumer energy demand. Most of this fuel is used for transport and in mobile off-road uses such as in the construction industry and agricultural vehicles (e.g. tractors). Electricity has the next largest share of consumer energy demand. It provides more than a quarter of total consumer energy, and is the dominant energy used by industrial, commercial and residential consumers. The direct use of gas, coal, geothermal, wood and other renewables makes up the balance.

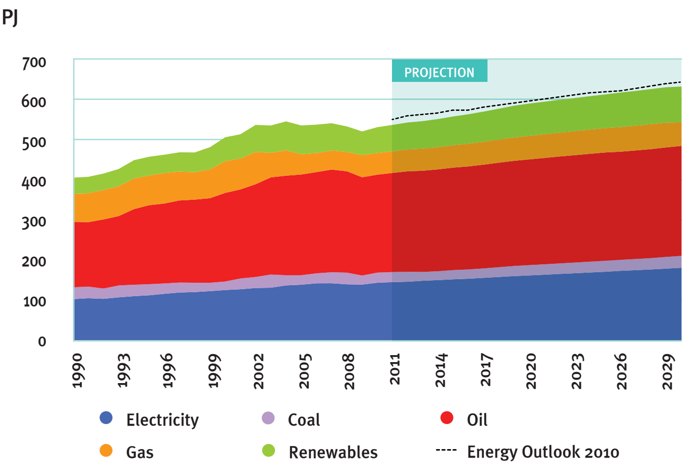
Consumer energy demand has increased at an average rate of 1.4% per annum since 1990. More recently a weaker economy has been accompanied by supressed growth in energy demand. In the *Reference Scenario*, lower than historical rates of population and economic growth, higher energy prices, energy efficiency improvements and changes in the transport sector see energy demand growth averaging around 1% per annum out to 2030.

In the *Reference Scenario*, transport plays a strong role in slowing the growth in New Zealand's total consumer energy demand. Over the last few decades New Zealand's light vehicle ownership rate (per capita) has increased to one of the highest rates in the world and has now reached saturation. 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. New Zealand motorists should benefit from these more efficient vehicles as they gradually replace the existing fleet. In the *Reference Scenario* these factors combine to more than halve the growth in oil demand, from historical rates of over 2% per annum to well below 1% per annum by 2030.

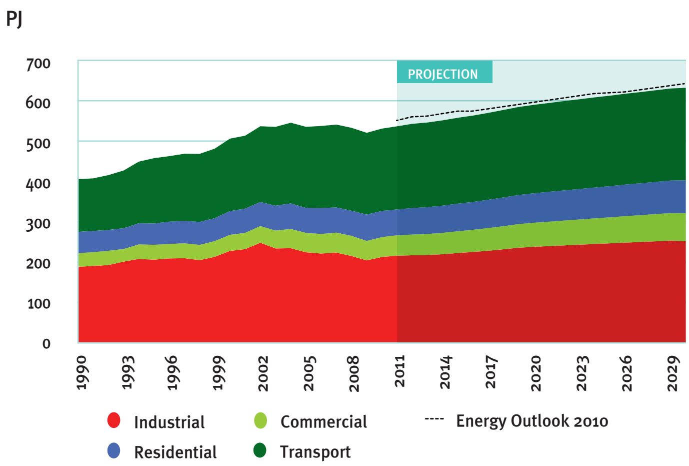
Modelling for New Zealand's *Energy Outlook 2011* includes domestic biofuel production and an uptake of electric vehicles in response to increasing oil prices. Although higher oil prices and exchange rates make biofuels and electric vehicles more economic than in *Energy Outlook 2010*, forecast uptake rates for these technologies remain low in the *Reference Scenario*. In 2030 less than 2% of total transport energy demand comes from electricity and biofuels.

Although New Zealand has a mature oil extraction and processing industry, for technical and economic reasons imported oil continues to dominate in the *Reference Scenario*. Supplying energy to New Zealand's transport sector 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



Reference Scenario

New Zealand's non-transport consumer energy demand can be split into three broad sectors: industrial, commercial and residential, contributing 40%, 9% and 12% of total demand respectively in 2010. The industrial sector includes agriculture, forestry, fishing, mining, manufacturing, and construction. The commercial sector covers trade, hospitality, communications services, business/financial services, and public services.

A comprehensive review of the sub-sector demand models used to forecast New Zealand's *Energy Outlook* has resulted in MED adopting sectoral GDP forecasts (from NZIER) in place of national GDP forecasts[4]. The industrial sector GDP forecast used in *Energy Outlook 2011* grows at around 1.4% per annum out to 2030, whilst the commercial sector GDP forecast grows at around 2.2% per annum. At an "economy wide" level this equates to around 2% per annum long-term growth, which is consistent with long-term Treasury forecasts. In the *Reference Scenario*, energy demand for the industrial sector increases by a further 12% by 2030. Over the same period, higher economic growth in the commercial sector sees its energy demand increase by nearly 40%.

In the industrial sector, electricity made up the largest share of energy demand in 2010 at 29% of the total, followed by biomass at 22%, and gas at 19%. Industrial plants often require a heat source that can best be provided by the on-site combustion of fuel rather than from electricity. In the *Reference Scenario* biomass increases its contribution to industrial energy demand (to 26%), while gas reduces its contribution (to 16%) by 2030. This drop in gas demand is largely because methanol production is assumed to be scaled back from 2030 as gas supplies tighten and gas prices rise. A small number of other specific large industrial energy users (including basic metals production and oil product refining) are forecast separately from the main industrial sector model. These large users are assumed to continue operating at their current level of production.

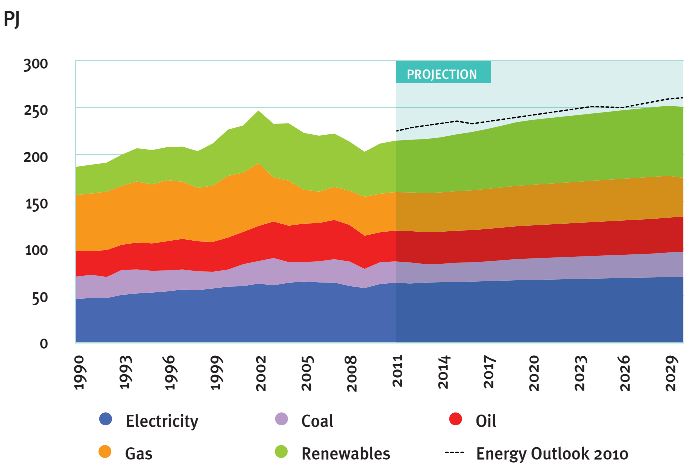
In *Energy Outlook 2011* forecast industrial energy demand growth is around 0.8% per annum out to 2030. Total industrial demand is lower than in *Energy Outlook 2010* for the entire forecast. Significant revisions made to New Zealand's historical energy data, which have shifted energy demand between the industrial and commercial sectors, impacting on the modelling results. Industrial wood energy demand is now linked directly to the wood processing sub-sector GDP forecast, which has the effect of increasing wood demand growth in the short term but limiting growth after 2020. For more information please see the technical documents accompanying this article.

In the commercial sector, electricity made up almost two thirds of energy demand in 2010. Of all the fuels used by the commercial sector, electricity demand has also experienced the greatest growth over the last 20 years. Out to 2030, the *Reference Scenario* sees steady growth in the commercial sector's energy demand, averaging 1.7% per annum out to 2030. Electricity continues to be the dominant energy source.

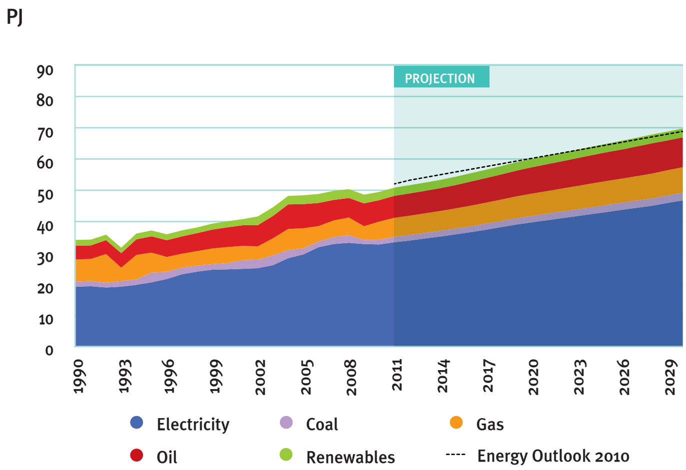
The residential sector covers households' use of energy but excludes motor-vehicle use (which is included under transport demand). In 2010 almost three quarters of residential energy demand was electricity. In the *Reference Scenario* electricity continues to dominate and accounts for almost all of the forecast growth in demand.

Residential energy demand is relatively resilient to the economic cycle and grows broadly in line with the growth in household numbers, averaging over 1% per annum out to 2030. The *Reference Scenario* forecasts that residential energy consumption per household will remain near current levels in the future, with energy efficiency improvements being balanced by increased consumption as households become wealthier.

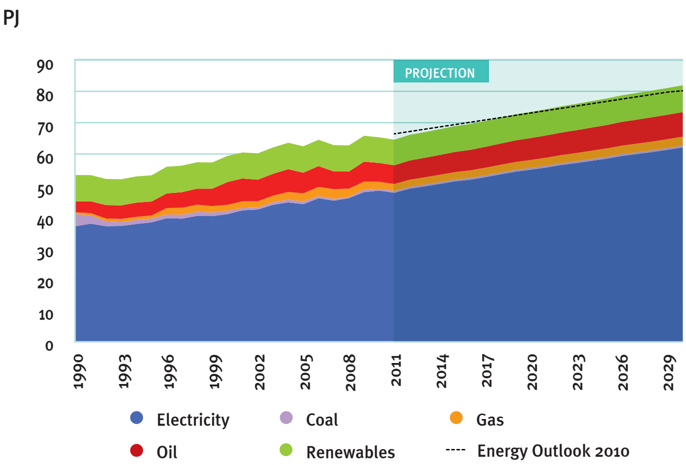
Industrial Demand by Fuel Type



Commercial Demand by Fuel Type



Residential Demand by Fuel Type



[4] A technical report "Review of MED's Demand Forecasting Methodology" is available on the MED website alongside the *Energy Outlook 2011*.

Reference Scenario

Electricity is the dominant energy type used by industrial, commercial and residential consumers. From 1992 to 2005 electricity demand increased rapidly, averaging over 2.2% per annum growth. Since then growth has slowed to average only 0.3% per annum.

In the *Reference Scenario*, growth in total electricity demand returns, with an improving economy, averaging 1.2% per annum out to 2030. Prior to 2025 this is a similar rate to the growth seen in *Energy Outlook 2010*. Commercial sector electricity demand increases by an average of 1.8% per annum, whilst industrial sector demand grows by only 0.5% per annum. These energy demand growth rates reflect the relative economic growth within these sectors. Electricity demand for both aluminium and steel production (which together made up over 45% of industrial electricity demand in 2010) is assumed to remain at current levels. Residential electricity demand grows close to its historic rate at around 1.4% per annum.

There is a great deal of uncertainty over what the precise make-up of New Zealand's future electricity supply will be, as a number of factors could shift it towards, or away from specific technologies. Exchange rates and steel prices affect the capital cost of building new plants, especially renewables, whilst fuel and carbon prices affect the cost of running thermal plants. Gas supply is also critical, with new gas plants unlikely to be built without long-term supply contracts[5].

In the *Reference Scenario* the installed capacity of geothermal and wind generation each increase by around 850 MW by 2030. The *Reference Scenario* also sees a net 390 MW increase in gas baseload capacity by 2030. A large plant is built in Auckland in 2026 and all existing gas stations are refurbished and remain in operation.

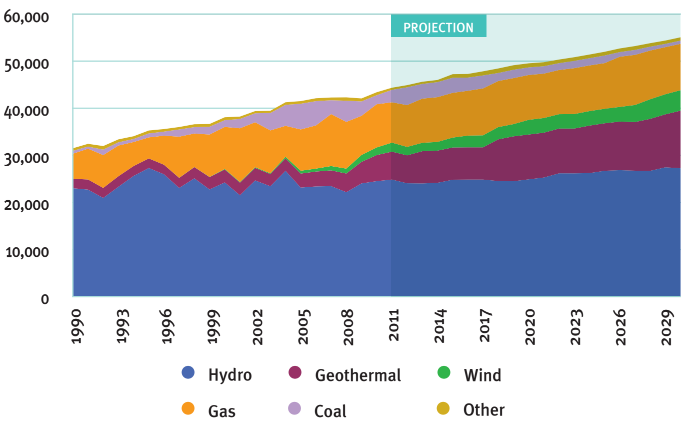
The *Reference Scenario* sees 600 MW of gas and diesel peakers built by 2030 to replace the dry year backup role of the aging Huntly units and provide backup for wind generation. This is less than the 740 MW of peakers forecast in the *Energy Outlook 2010*. This change is due to improved modelling of peak generation, a slight decrease in the peak demand forecast, and the additional 390 MW of baseload gas capacity. The additional baseload gas capacity will have a degree of flexibility, partially mitigating the need for additional peakers.

Around 350 MW of smaller scale hydro developments are built by 2030. In the previous *Energy Outlook* around 1500 MW of new hydro was built. The capital costs for some of the large-scale hydro schemes have been revised upward. The additional baseload gas capacity also reduces the need for these hydro developments. For more information on changes made to the electricity supply modelling, see the accompanying Technical Guide.

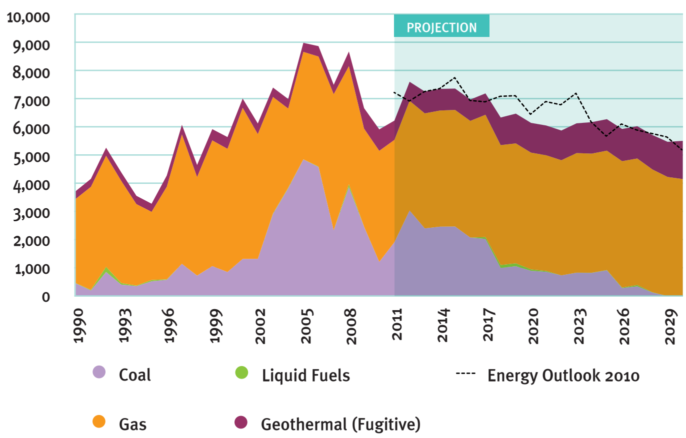
Emissions pricing is a substantial risk for coal generation, so we assume there is no new investment in this technology and the existing Huntly units are phased out over time. As a result total electricity emissions (including fugitive geothermal emissions) are forecast to be 7% lower in 2030 than they were in 2010.

For most of the forecast period, electricity emissions are similar to those forecast in the *Energy Outlook 2010*. Emissions from 2018 to 2025 are lower than previously forecast due to the earlier decommissioning of a Huntly coal unit (in line with increased coal price assumptions[6]) and a new gas baseload plant (in Auckland) being built slightly later than in the *Energy Outlook 2010*.

Electricity Generation by Fuel Type[7]



Electricity Greenhouse Gas Emissions by Fuel



5 Gas supply and pricing is based on an MED model that projects future discoveries in Taranaki and other regions. See the accompanying Technical Guide for further information.

6 See "Coal Prices in New Zealand Markets: 2011 Update" by Covec.

7 The *Energy Outlook 2010* comparative line has been omitted from this chart as the previous chart excluded some on-site generation. The above chart aligns with information presented in the *Energy Data File 2011* (with applicable data updates since its publication).

Reference Scenario

Since 1990, New Zealand's transport energy demand has varied with the size and structure of the economy, the population, and our travel and vehicle choices. From 1990 to 2003, transport energy demand increased by around 50% in line with strong economic growth. From 2004 to 2007 the economy continued to grow, but growth in transport energy demand slowed considerably. Since then, higher oil prices, the subdued economic climate and more efficient vehicles entering the fleet from Europe and Asia have held off growth in transport energy demand.

While domestic air travel has increased over the last decade with more competition and lower fares, land transport still accounts for over 90% of total transport energy demand. On the road, our cars, trucks and motorcycles almost all have internal combustion engines fuelled by petrol and diesel.

Over time New Zealand has developed one of the world's highest per capita car ownership rates. Historically this was aided by the wide availability of affordable vehicles, limited public transport networks outside the main centres, and relatively cheap fuel due to lower fuel taxes than most other nations. More recently trends indicate New Zealand car ownership rates have reached near saturation.

In the *Reference Scenario*, with the economic recovery, growth in transport energy demand is expected to return, but at a slower rate than before. Fuel prices move upward, with petrol reaching $2.66 per litre (in real terms) by 2030. Vehicle fleet efficiency also improves. Out to 2030 a growing economy will see increased freight movement and a steady increase in diesel demand. With the light vehicle fleet near saturation levels and the increasing popularity of diesel, petrol demand remains flat in the short term and decreases by 2030.

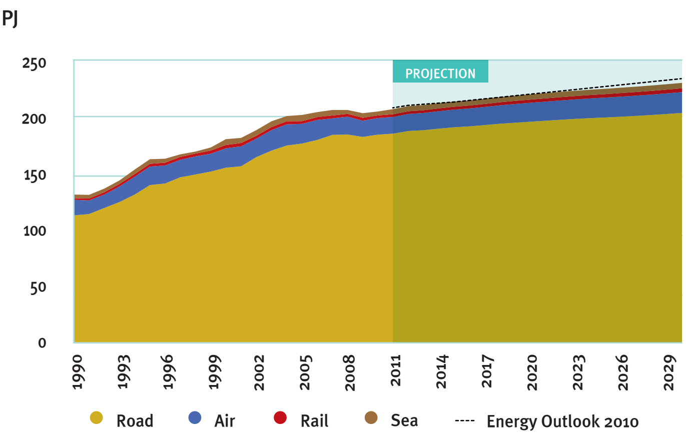
Although the *Reference Scenario* sees oil products remain the dominant transport fuel out to 2030, electric vehicles and biofuels are expected to play a part. The extent to which this eventuates will depend heavily on fuel prices, vehicle prices, technological development and the level of market acceptance.

In the *Reference Scenario*, we assume electric vehicles remain more expensive than conventional vehicles. The higher up-front cost for electric vehicles remains the biggest barrier to their widespread uptake. With the current price premium, the *Reference Scenario* sees sales of full electric (EV) and plug-in hybrid (PHEV) vehicles growing to a market share of 13% of all new light private vehicles sold in 2030 and these vehicles making up around 5% of all vehicle kilometres travelled that year.

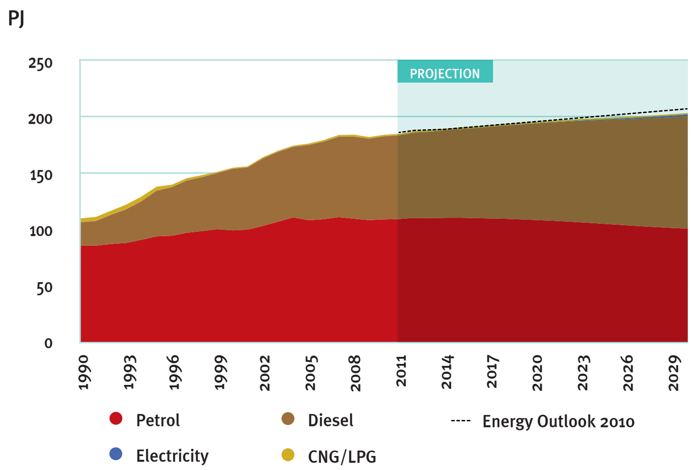
New Zealand has a small "first generation" biofuel (ethanol and biodiesel) production industry. Almost all production is blended with traditional oil products, and these blended products can then be used in modern internal combustion engines. First-generation biofuels have a number of inherent limitations and better outcomes are expected from the development of "second generation" biofuels, where biomass from a range of non-food crops is converted into biofuels in more efficient ways than is possible with first-generation biofuels. Their uptake will require large-scale industrial investments with associated business risk, including that of competing with a volatile oil price. We assume second-generation biofuels become economic in the late 2020s as diesel prices rise.

Other alternatives such as coal-to-liquids and hydrogen fuel cells may also become economic. These alternatives have a range of technological, environmental and economic issues to overcome and are excluded from the *Reference Scenario*.

Transport Demand by Mode



Road Transport Demand by Fuel Type



Sensitivity Analysis

Energy demand is generally closely linked to GDP growth. Strong economic growth in New Zealand in the decade from the mid-1990s was coupled with strong growth in energy consumption. Conversely, lower economic growth in recent years has been accompanied by a flattening of growth in energy consumption.

In the *Reference Scenario* and the *Sensitivity Analysis*, GDP forecasts for individual sectors of the economy are used as key inputs for forecasting sub-sector energy demand. These forecasts are sourced from NZIER. The NZIER (and Treasury) forecasts see New Zealand's real GDP increase by around 50% on today's figure by 2030. As the economy recovers, growth is seen to rebound to higher levels for the rest of this decade, trending to near 2% per annum growth out to 2030.

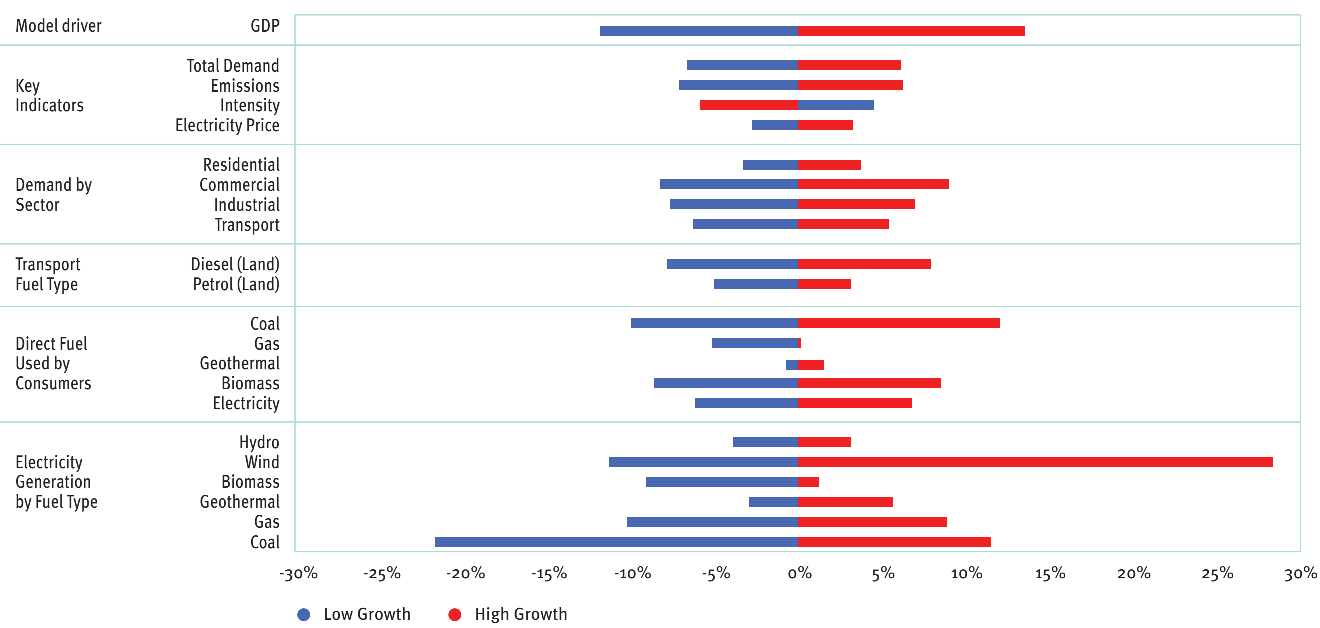
In the high-growth sensitivity case, we examine the sensitivity of our *Reference Scenario* to GDP growth that is 1% per annum higher than in the *Reference Scenario*. With long-term growth trending to near 3% per annum, New Zealand's real GDP grows by around 80% by 2030.

In the low-growth sensitivity case, GDP growth is modelled at 1% per annum below the *Reference Scenario* forecast, producing a long-term average of less than 1% out to 2030. With this reduced growth New Zealand's real GDP increases by only a further 20% from its current value by 2030.

Highlights:

- Higher GDP sees increased energy consumption for all consumers. Industrial consumers show the greatest sensitivity to GDP growth. Transport energy demand also increases as freight volumes rise. Residential consumers are wealthier and have a higher energy demand.
- By 2030 the high economic growth sensitivity case sees energy intensity fall to just over half that of 1990. A faster growing economy sees a relative increase in commercial sector GDP, which has lower energy intensity than industry. Combined with energy efficiency improvements focused on the industrial sector, energy intensity improves faster than in the *Reference Scenario*. In the low-growth sensitivity case, energy intensity still reduces but at a slower rate.
- The increase in transport sector demand, combined with a higher level of gas, coal and geothermal electricity generation, mean total energy sector emissions are 6% higher in the high-growth sensitivity case than in the *Reference Scenario*.
- Wholesale electricity prices are only slightly higher in the high-growth sensitivity case than in the *Reference Scenario*. 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.
- In the high-growth sensitivity case, increased energy demand from all sectors pushes gas prices up sooner than in the *Reference Scenario*.
- Investment in new wind generation capacity is substantially higher in the high-growth sensitivity case, meeting most of the additional electricity demand. New Zealand has a large number of identified potential wind farm sites and, with the economics of wind sitting somewhere between that of geothermal and hydro, it is likely that it will provide a substantial proportion of the new generation required to 2030.
- In the low-growth sensitivity case, Huntly switches completely to dry year reserve by 2018, compared to 2026 in the *Reference Scenario* and high-growth sensitivity case. Electricity emissions from coal drop close to zero, and total electricity emissions drop significantly in 2018 as a result.

Average % Change from the Reference Scenario, 2015 to 2030



Sensitivity Analysis

This *Sensitivity Analysis* explores the response of the energy sector to variations in the future oil price. Sustained higher oil prices will encourage the uptake of fuel-efficient vehicles and improve the economics of oil exploration and production in New Zealand. This could have significant impacts on the wider economy. As gas production is generally associated with oil production, it can be expected that any increase in 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 2010 Current Policies Scenario. In this scenario, real oil prices are projected to rise steadily from current prices and reach US$130 per barrel (bbl) by 2030.

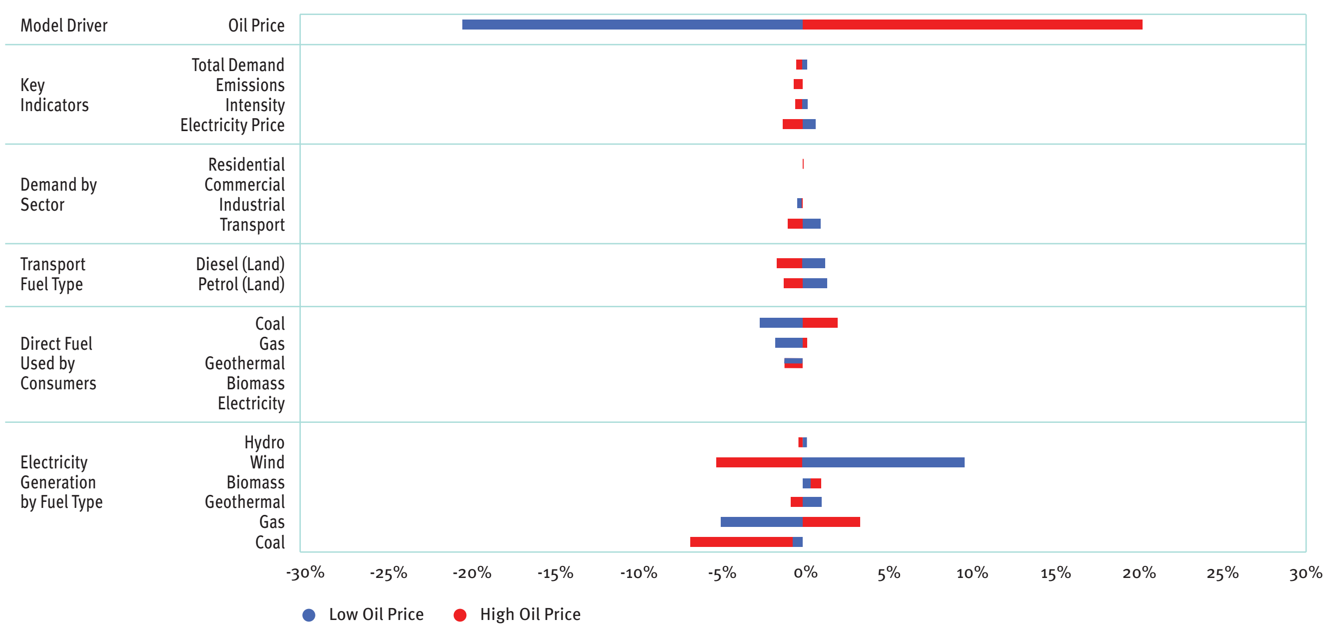
In the high oil price sensitivity case, international crude oil prices in 2030 are assumed to be around 30% higher than the *Reference Scenario* and to reach US$170 per barrel in real terms. This equates to pump prices of around $3.15 and $2.50 per litre in real terms for petrol and diesel respectively. These prices are lower than those published in the *Energy Outlook 2010* high oil price sensitivity case, mainly as a result of using a higher long-term exchange rate. In the low price sensitivity case, crude oil prices are assumed to be US$90 per barrel in real terms for the entire forecast period.

The price elasticity of demand for oil products is low. Within the oil price sensitivity cases it is assumed that price elasticity relationships observed at historical prices hold at the new price levels tested. For oil prices outside historical bounds this assumption may not hold.

Highlights:

- New Zealand continues to see over 30% of primary energy supply coming from oil out to 2030, even with the international oil price sitting 30% higher than in the *Reference Scenario*. Annual transport demand in 2030 is only expected be 2.5% less in the high price sensitivity case. Over three quarters of oil demand is for transport purposes.
- Higher fuel prices see motorists purchasing smaller and more fuel efficient light vehicles. Battery electric and plug-in hybrid electric vehicles account for 17% of new private car purchases in 2030 (up from 13% in the *Reference Scenario*).
- At higher oil prices some alternative fuels (such as second generation biofuels) 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 2020s.
- In the low oil price case, reduced supply of gas limits gas-fired electricity generation, which is offset by an increase in wind and coal generation.
- Generation from coal and wind is reduced in the high oil price case, as the high gas supply leads to increased gas generation.

Average % Change from the Reference Scenario, 2015 to 2030



Sensitivity Analysis

In this *Sensitivity Analysis*, exchange rates are varied, which affects the domestic price of imported fuel and capital. These changes have an impact on consumer energy demand (predominantly in the transport sector), and on future electricity supply.

New Zealand's transport system is heavily reliant on oil products, almost all of which are imported or refined in New Zealand from imported crude oil. The great deal of uncertainty associated with future crude oil prices is compounded with more uncertainty when exchange rates are also considered. The exchange rate will also affect the affordability of new vehicles, as all major motor vehicle brands are manufactured overseas.

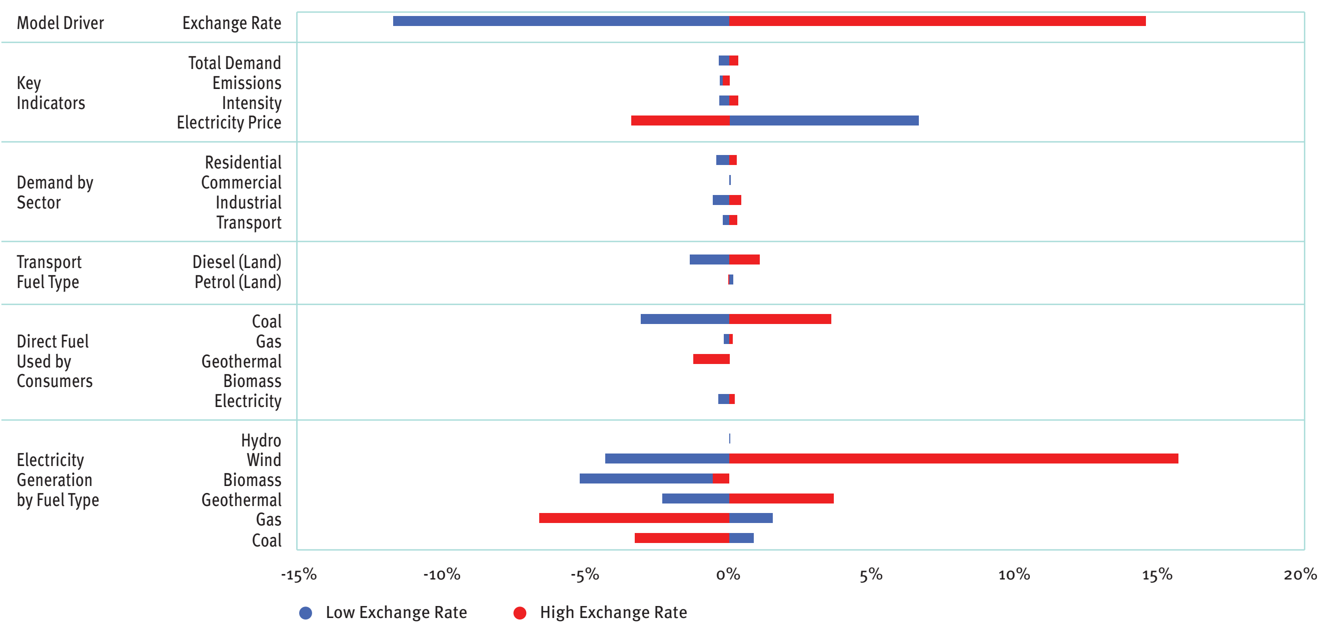
Similarly, much of the energy infrastructure deployed in New Zealand is imported. Electricity turbines and control components are typically manufactured in Europe, Japan or the US, with their delivered price fluctuating with the exchange rate. For this reason investment decisions in these technologies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

In the *Reference Scenario*, exchange rates are consistent with the NZIER GDP forecast assumptions, and trend downwards from current high levels towards a long-run average rate of 0.66 US$/NZ$. The high exchange sensitivity case sees the New Zealand dollar settle 15% higher, at around 0.76 US$/NZ$, giving lower import costs for fuels and equipment. In the low exchange sensitivity case, the New Zealand dollar depreciates a further 15% below the *Reference Scenario* to settle at 0.56 US$/NZ$.

Highlights:

- The price of petrol and diesel is highly dependent on the exchange rate. However, low price elasticities mean large price variations have only a small impact on demand.
- In the high exchange rate sensitivity case, the lower import costs of motor vehicles enables a quicker uptake of electric vehicles. However, petrol and diesel vehicles continue to dominate new vehicle purchases as fuel prices remain lower.
- A higher 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 but more so for capital intensive renewables such as wind and geothermal;
  - the relative improvement in the economics of renewables results in more wind and geothermal, at the expense of coal and gas generation; and
  - the cost of imported coal is reduced; however, this is offset by the improved economics of new renewable generation.
- In the low exchange rate sensitivity case, more electricity is generated from gas and coal at the expense of geothermal and wind generation, which all become relatively more expensive. The natural gas price is not directly affected by the exchange rate as there are no gas imports or exports in the *Reference Scenario*.
- The electricity price forecast is linked to the LRMC of new generation. The high exchange rate sensitivity case results in a 3% fall in average prices relative to the *Reference Scenario*, while the low exchange rate sensitivity case results in a 7% increase in prices.
- In the low exchange rate sensitivity case, higher domestic prices for oil products increase the uptake of domestically produced biofuels. New vehicles also cost more, so motorists hold on to their vehicles for longer, thereby increasing the average age of the vehicle fleet.

Average % Change from the Reference Scenario, 2015 to 2030



Sensitivity Analysis

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

The *Reference Scenario* assumes an emissions price of $25 per tonne of carbon dioxide equivalent (CO_2-e) emitted from 2013. Two alternative sensitivities are considered, a no emissions price sensitivity case and a sensitivity case where the emission price rises to reach $100 per tonne by 2020 and remains at that level out to 2030.

For the high emissions price case ($100 per tonne of CO_2-e from 2020), 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. 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 legislation. No assumptions around industry expansion or closure as a result of emissions pricing have been made.

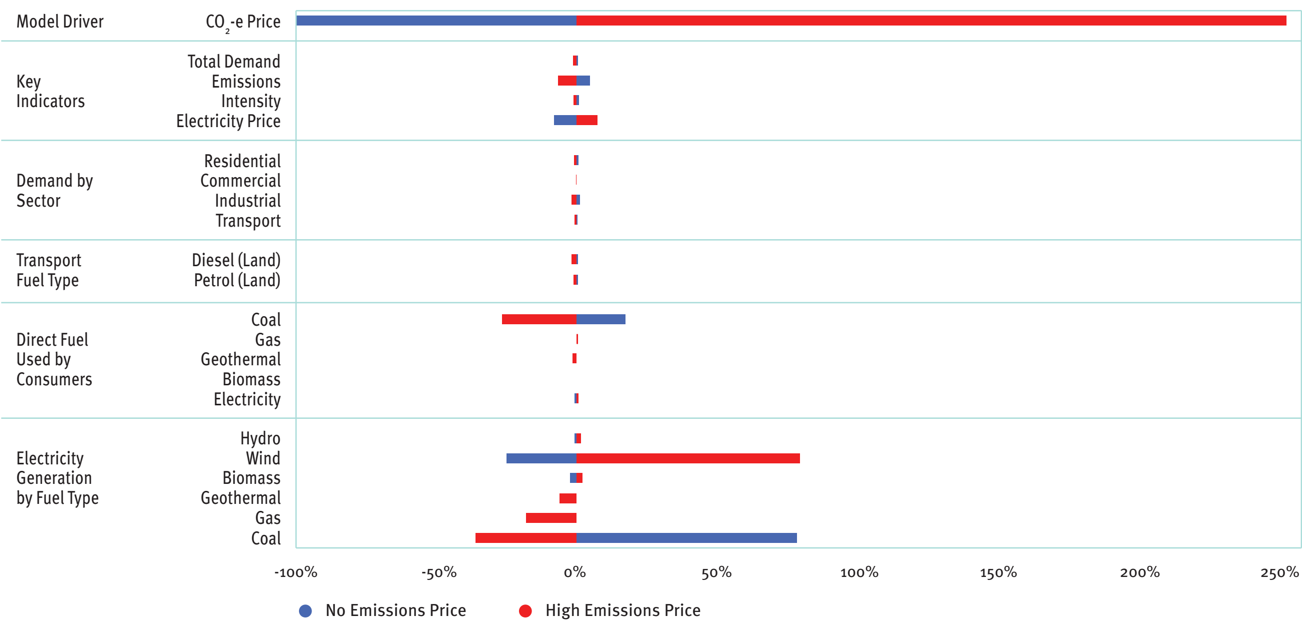
In both the *Reference Scenario* and the high price sensitivity case, the increase in energy prices due to the cost of carbon drives industry (and New Zealand as a whole) to become more energy efficient.

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

Highlights:

- An increase in the emissions price from $25 per tonne to $100 per tonne results in a 7% fall in total energy emissions.
- A $100 per tonne emissions price increases the petrol price by a further 20 cents per litre, which results in only a 0.8% fall in petrol transport demand relative to the *Reference Scenario*.
- Diesel demand is more responsive to the emissions price, with the $100 per tonne emissions price causing a 1.4% fall in demand relative to the *Reference Scenario*.
- A higher emissions price will encourage the uptake of transport alternatives; however, the relatively small increases in petrol and diesel prices result in marginal increases in biofuel and electric vehicle demand. In the high emissions price sensitivity case, electric vehicle demand increases to 2 PJ per annum by 2030 while biodiesel demand increases to 3.4 PJ. Combined, these represent less than 2.5% of total transport energy demand in 2030.
- In the high emissions price sensitivity case, wind generation increases by 80% while coal reduces by 36% relative to the *Reference Scenario*. The 250% (average) increase in the emissions price results in a 8% rise in the electricity price relative to the *Reference Scenario*.
- In the no emissions price sensitivity case, coal generation increases by 79% while wind falls by 25% relative to the *Reference Scenario*. A new 560 MW coal plant is built in 2028 and in the early 2020's one of the Huntly units is refurbished and remains in operation until 2040 (in the *Reference Scenario* all the Huntly units are fully decommissioned by 2030).
- With no emissions price the electricity price is around 5% lower than in the *Reference Scenario*.

Average % Change from the Reference Scenario, 2015 to 2030



Assumptions

www.med.govt.nz/sectors-industries/energy/energy-modelling/modelling

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

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 of the relationships between different variables, there are inherent limitations that need to be taken into account when interpreting results. In particular, the future is uncertain and we do not attempt to model the subtleties of commercial decision-making or barriers to investment. The models also consider only a sub-set of the economy, so second-order implications are ignored.

Reference Scenario

- GDP growth follows projections of sectoral economic growth produced by NZIER. At a national level, both Treasury and NZIER forecasts see New Zealand's real GDP increase by around 50% on today's figure by 2030. As the economy strengthens, growth is seen to rebound to higher levels for the rest of this decade, trending to near 2% per annum growth out to 2030.
- Population and household growth forecasts are medium fertility, medium mortality and medium migration forecasts from Statistic New Zealand and are unchanged from *Energy Outlook 2010*.
- Exchange rates are consistent with those used in the NZIER GDP forecasts. From now until 2016, exchange rates trend downwards towards a long-term rate of 0.66 US$/NZ$ and remain at this rate indefinitely. This long-term rate is higher than the 0.60 US$/NZ$ used in *Energy Outlook 2010*.
- Oil prices are assumed to follow the New York Mercantile Exchange (NYMEX) futures price until 2014, and trend upwards towards the International Energy Agency's World Energy Outlook (WEO) 2010 current-policies projections. By 2030 the price is forecast to reach US$130 per bbl in real terms (revised by the IEA from $115 per barrel in WEO 2009).
- An emissions price of $25 per tonne of carbon dioxide is assumed from 2013. This is lower than the $50 per tonne assumed in *Energy Outlook 2010*, reflecting lower carbon prices worldwide.
- No specific assumptions have been made about the construction of new large industrial plants. Similarly, no assumptions around the expansion or closure of existing plants as a result of emissions pricing have been made.
- Existing large energy users (with the exception of methanol production) are assumed to maintain production near current levels.
- Future gas discoveries are determined by an MED Oil and Gas simulation model. A separate methodology document explains this modelling in more detail. The result is an average of around 125 PJ per annum of gas production from new discoveries between 2019 and 2030. There are no gas imports or exports.
- Gas prices are based on the modelled intersection of total gas demand and the supply curve. The supply curve is represented by the economic "break-even" gas prices produced from the MED Oil and Gas model. Prices follow a similar trajectory to *Energy Outlook 2010*, where prices remained flat until the mid-2020s.
- Two units at Huntly coal fired power station are switched to dry year reserve in 2012 and 2015 respectively. No further coal stations are built.
- Decommissioning of the two remaining Huntly coal units is determined by the "GEM" model. GEM decommissions these units in 2018 and 2026.
- Ownership rates of light passenger and light commercial vehicles increase only slightly above current levels.
- Purchases of light diesel vehicles make up around 90% of new light commercial vehicles and 25% of new light private vehicles in 2030.
- Purchases of electric vehicles make up 7% of new light commercial vehicles and 13% of new light private vehicles in 2030.

Sensitivity Analysis

GDP

I. Low Growth – 1% per annum below the *Reference Scenario* GDP forecast.

II. High Growth – 1% per annum above the *Reference Scenario* GDP forecast.

Oil Price

III. Low Oil Prices – US$90 per bbl in real terms for the entire forecast period.

IV. High Oil Prices – 30% higher than the *Reference Scenario* in 2030, reaching US$170 per bbl in real terms.

Emissions Price

V. No Emissions Price

VI. High Emissions Price – rising from current levels to $100 per tonne from 2020 onwards.

Exchange Rate

VII. Low Exchange Rate – 15% lower than long-term average exchange rate.

VIII. High Exchange Rate – 15% higher than long-term average exchange rate.

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

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