New Zealand's Energy Outlook 2009/2010

Changing Gear

How could New Zealand reduce its reliance on imported oil?

Welcome

One of the key challenges presented in the *Reference Scenario* is New Zealand's ongoing reliance on imported oil. From an energy security perspective this dependency exposes New Zealand to the variability and uncertainty of international oil prices and potential supply disruptions. It also has a significant impact on New Zealand's balance of payments.

The *Reference Scenario* also saw ongoing increases in greenhouse gas emissions from the energy sector – by 2030 energy sector emissions could be 40% above 1990 levels. The Transport fleet is largely responsible for the increased emissions.

The Changing Gear scenario considers an alternative future. The driving forces behind this scenario are higher international oil and emissions prices than in the *Reference Scenario*. These price increases see demand for oil, coal and gas fall in favour of non-fossil alternatives, and improvements in energy efficiency. In the near term, motorists respond by making greater use of public transport in metropolitan areas and purchasing more efficient internal combustion and hybrid vehicles. From 2020, electric vehicles make up an increasing portion of the light vehicle fleet and we see development of a substantial domestic biofuel industry. There is widespread switching from coal and gas to wood for industrial heat.

Two pathways are considered: one with a very high oil and emissions price which sees rapid and widespread uptake of non-fossil fuels and energy efficiency; and one with somewhat lower prices with consequently lower uptake. It should be noted that none of these scenarios set out our expectations around future oil and emissions prices.

This scenario draws on both New Zealand and international research and case studies on the potential for alternative fuels and vehicles and their likely costs. A detailed list of assumptions and references is included on the back page of this article.

Reference Scenario and the *Changing Gear Scenario*

Please read this publication in conjunction with the *Reference Scenario* publication shown above.

Key messages

- A considerable increase in the cost of oil could see significant improvements in energy efficiency and a reduction in the consumption of fossil fuels.
- With reduced demand for oil, New Zealand's oil security improves by 30% by 2040 in the High Uptake Case.
- Energy sector greenhouse gas emissions could fall below 1990 levels by 2040.
- By 2040 in the High Uptake case, biomass makes up almost 25% of the country's primary energy supply. Much of this biomass is used for the production of advanced biofuels.
- The direct use of biomass for heat doubles by 2040 in the Low Uptake case and increases over 2½ times in the High Uptake case.
- Electric vehicles and improved vehicle efficiency greatly reduce the energy used by the country's vehicle fleet and reduces New Zealand's reliance on imported oil.
- Widespread uptake of electric vehicles has only a limited impact on total electricity demand.
- If electric vehicles are re-charged in off-peak times, there is unlikely to be any significant change in wholesale electricity prices.

Want a closer look?

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

A publication of the Ministry of Economic Development
ISSN 1179-3996 (print) ISSN 1179-4011 (online)

Ministry of Economic Development
Manatū Ōhanga

Net Oil Import Dependency is the ratio of net imports[1] to consumption. It is often used as an indicator of oil security because it shows how reliant a country is on oil imports to meet local demand. This ratio can be improved (i.e. made smaller) by either reducing demand or increasing local production.

Since 1990, New Zealand's Net Oil Import Dependency has experienced two periods of significant improvement. In 1996 as production from the Maui field increased markedly and then from 2006 as production from the Tui, Pohokura and then Maari fields began.

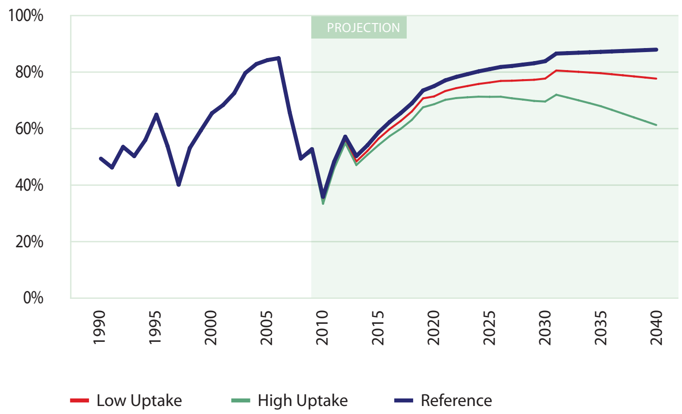
In the *Reference Scenario* New Zealand's Net Oil Import Dependency increases from record low levels back to record high levels post 2030 (>90% dependency). This reflects the relatively quick tapering off of production from both Tui and Pohokura, and the newer Maari and Kupe fields, modest production from "new" discoveries[2] and continued strong growth in demand for oil (particularly diesel).

In this alternative scenario New Zealand's long–term oil security is permanently improved relative to the *Reference Scenario*. Reduced demand for oil is achieved through efficiency improvements to the fleet, the uptake of electric vehicles and the establishment of large-scale local biofuel production.

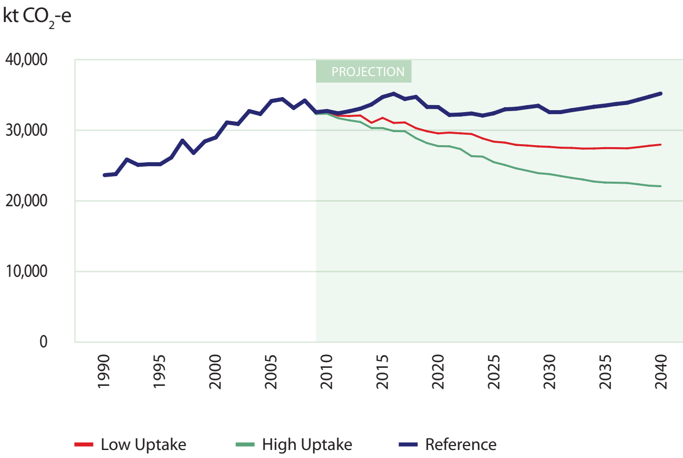
These changes reduce New Zealand's exposure to volatile international oil markets and help improve the balance of payments by reducing import costs. By 2040, net oil import dependency is improved by ~10% and ~30% for the Low and High Uptake cases relative to the *Reference Scenario*. Importantly, these changes have a permanent positive impact on oil security and also highlight how important demand-side measures are in reducing New Zealand's exposure to international oil markets.

In this scenario, total **Energy Sector Greenhouse Gas Emissions** reduce significantly from the Reference Scenario. Between 2012 and 2020, emission reductions occur in electricity generation as the higher emissions prices are assumed to bring forward the decommissioning of the Huntly coal station. Post 2020, ongoing efficiency improvements in the vehicle fleet, the uptake of electric vehicles and the increased use of liquid biofuels and biomass for heat, result in large reductions in emissions relative to the *Reference Scenario*. By 2040, emissions in the Low Uptake case are ~20% lower than seen in the *Reference Scenario*, but still 17% higher than 1990 levels. With higher oil and emissions prices in the High Uptake case, energy sector emissions are reduced to 7% below 1990 levels by 2040. These emission reductions are achieved in a scenario that represents a significant break from the past in terms of the country's energy mix, particularly for our transport system.

Net Oil Import Dependency (Oil Security)



Energy Sector Greenhouse Gas Emissions



[1] Net imports = imports less exports. In New Zealand's case, although almost 95% of locally consumed oil is imported, our Net Oil Dependency is much lower because of local production, which is mostly exported as it fetches a premium price on the international market.

[2] 40PJ of additional production from "new discoveries" is included. This is based on the annualised historical average.

Primary energy supply is the total amount of energy available for end use and energy transformation.[3] This includes local and imported non-renewable energy sources such as coal, oil and gas and renewable energy sources such as hydro, wind, geothermal, bioenergy and solar energy.

New Zealand's primary energy supply is dominated by fossil fuels (particularly natural gas and imported oil) and has been increasing by around 2% per annum. Since the mid-1970's fossil fuels have on average contributed ~67% of New Zealand's total primary energy supply, reaching a high of 74% in 2001 at the peak of Maui gas production.

In the *Reference Scenario* the dominance of fossil fuels is projected to reduce slightly as a significant increase in geothermal electricity generation is foreseen. However, the use of imported oil continues to grow in absolute terms.

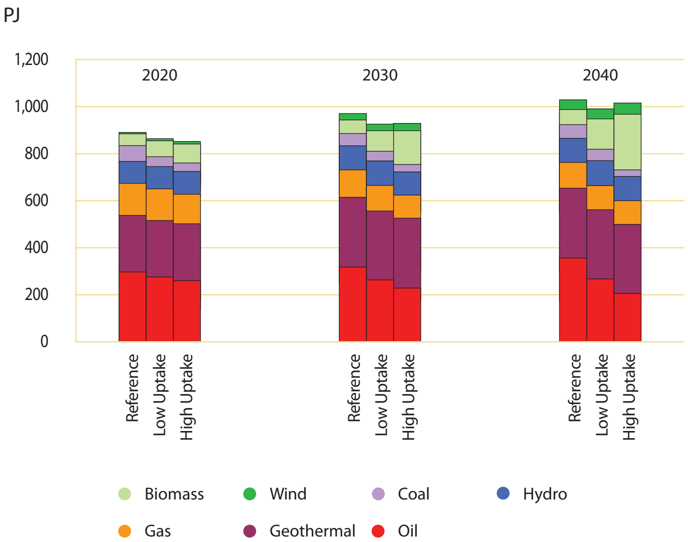
In this alternative scenario, demand for imported oil declines as a consequence of vehicle efficiency improvements, the uptake of electric vehicles and the development of a domestic biofuels industry. Biomass becomes a more significant source of primary energy in this scenario, making up almost 25% of the country's total primary energy supply by 2040. Almost 60% of this total is used for local biofuel production, with the remainder used for heat production or cogeneration.

This scenario sees local biofuel production of around 1.3 billion litres by 2040 in the High Uptake case (~20% of the country's total liquid fuel demand at that time). Production at this level would require a number of biofuel production plants,[4] representing a very substantial investment in a new industry with a range of significant business risks including unknown future oil prices. The potential for this rate of growth in a domestic biofuel industry is supported by Scion's analysis of biomass resource potential and the required level of investment in infrastructure to produce these quantities of biofuel. This scenario assumes that all barriers to this development are overcome and that the industry evolves at a measured rate such that feedstock supply can be ensured as plant is constructed around the country.

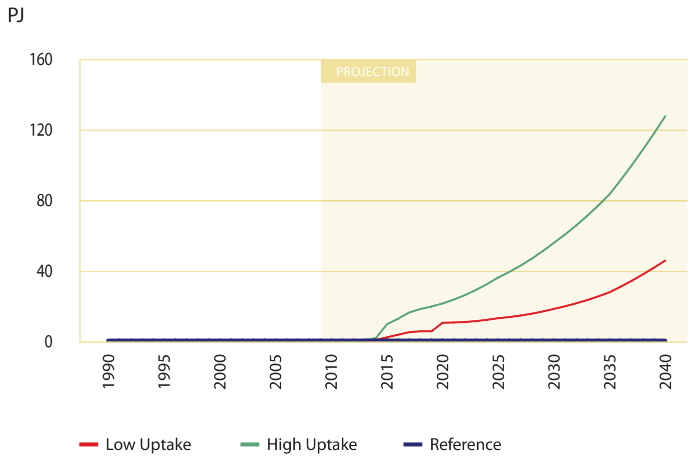
This level of biofuel production will certainly require the use of "second generation" production techniques sourcing biomass from a range of sources including algae, woody residues, and purpose–grown short rotation energy crops. These methods of biofuel production are still being developed and thus the timing and levels of such biofuel production are highly uncertain. In this scenario it is assumed that "second generation" technologies with low fuel cycle carbon emissions are proven and available by 2020 and have become an economic choice at a time when diesel prices exceed $2/litre.

Biofuels could also be imported into New Zealand. However, this would not have the benefit of reducing New Zealand's reliance on imported fuel. In addition, there is a growing body of research suggesting that New Zealand has considerable potential bioenergy resources that could form the basis for a competitive local biofuel industry. Importantly the consumption of this biofuel is not restricted to transport. It is assumed that the uptake of biofuel occurs across the economy on a basis proportional with the current consumption of diesel across the economy. This assumption results in the uptake of biofuel for non-transport activities in industry including agriculture, fishing, forestry, mining and construction.

Primary Energy Supply by Fuel



Biomass Demand for Biofuel Production



Primary Energy Supply Biomass (PJ)

	2010	2015	2020	2025	2030	2040
Reference Scenario	39	45	50	56	58	64
Low Uptake	39	49	65	75	86	128
High Uptake	39	57	81	112	146	235

[3] Energy Transformation in New Zealand includes petroleum refining, petrochemicals (methanol and urea), electricity generation (including cogeneration) and other transformation (including steel production).

[4] A biofuel production facility can be expected to have a capacity of ~100 million litres/annum.

Increased oil and emissions prices are expected to drive significant changes to the vehicle fleet. At an oil price of $180/barrel and emissions price of $100/tonne, petrol pump prices in real terms are over $3.50 /litre (incl. GST) in the High Uptake case by 2030. At such prices motorists are expected to dampen their travel demand, use public transport options where these are available in metropolitan areas and increasingly move to smaller and more fuel efficient vehicles. Vehicle efficiency gains in this scenario result from a myriad of technology options. These include engine improvements, such as the use of gasoline direct injection, turbochargers to increase the performance of smaller engines, advanced transmissions, stop-start technology, improvements in tyre performance, reductions in vehicle weight, and increased use of hybrid and other advanced technologies.

Greater demand for efficient light diesel vehicles is also expected as fuel prices increase. By 2025, light diesel vehicles make up ~30% of new light vehicle purchases and by 2030 the market share for vehicles with engines greater than 2 litres has reduced to relatively low levels.

In the *Reference Scenario*, travel and energy demand of the heavy vehicle fleet is seen to grow strongly, along with the expansion of the economy and associated freight movement. In this alternative scenario a greater share of the growth moves to rail and sea as these modes exhibit greater energy efficiency and lower cost for more freight movements. However, even in the High Uptake case there is still a more than doubling of road freight by 2040.

The higher oil prices also allow greater scope for alternative fuels and vehicles to be developed and become cost-competitive with petroleum products. The two major developments included in this scenario are electric vehicles and biofuels.

Throughout 2009 many of the world's major automotive manufacturers (including General Motors, Mitsubishi and Nissan-Renault) confirmed plans for the production of both full electric vehicles and plug-in hybrid electric vehicles. These are expected to start appearing from late 2010 and their initial uptake will be bolstered by a range of incentives being offered by governments throughout the OECD. Initially it is likely that the supply of these vehicles into New Zealand will be limited and purchase prices will be high. However, it is expected that by 2020 these vehicles will be widely available, relatively economic and become a popular option for light cars in urban centres and also for light commercial vehicles and small delivery trucks.

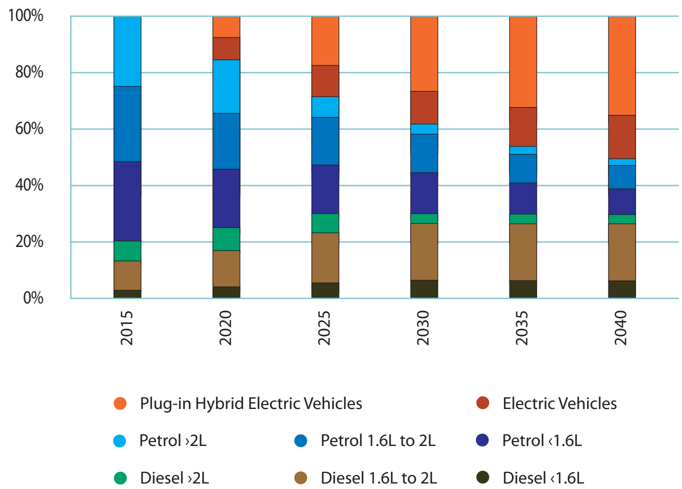
Although popular for the light fleet, electric vehicles will not represent the best solution for all motoring needs. In particular, larger commercial vehicles (i.e. trucks) and off-road machinery will remain reliant on the internal combustion engine. However, these remaining internal combustion engines can utilise locally produced biofuels to help reduce the reliance on imported oil.

Biofuels are already widely used around the globe with Brazil and the United States leading the way in ethanol use. However, with the exception of Brazil, where sugar cane grows rapidly, biofuels production has generally required support in the forms of government incentives or a mandated level of use. In New Zealand we have seen small-scale sales of blended ethanol encouraged by the exemption from excise duty and biodiesel supported by a grants scheme.

The prospect of "second generation" biofuels is appearing on the horizon. These fuels are expected to offer the advantage of being produced from specific energy crops grown on previously non-arable land and by more efficient conversion technologies than already seen for the "first generation" biofuels (ethanol and biodiesel). These biofuels have much lower fuel lifecycle emissions when compared with petroleum products.

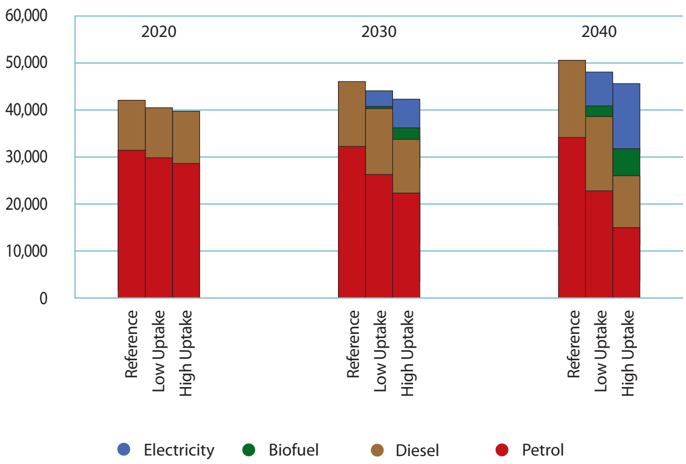
A wide range of feedstocks and conversion technologies has been identified and studied by researchers, with a number of these already being exhibited in pilot plants and the first commercial sized

Market Share of New Light Vehicle Purchases



Light Vehicle's Travel by Fuel

million vehicle kilometres travelled



plants in Europe and the United States. For example, the world's first commercial production plant to convert biomass into synthetic diesel fuel was opened by Choren in Freiburg, Germany in 2008. The plant, which has capacity to produce up to 18 million litres of fuel per year, uses a thermo-chemical pathway including Fischer-Tropsch synthesis to create synthetic diesel from wood waste.

The United Sates government has signalled that advanced biofuels are crucial to building a clean energy economy and reducing its dependence on imported oil. To this end the US government has established a renewable fuel standard and also invested in biofuels research and development grants. The renewable fuel standard requires the use of biofuels growing to some 36 billion gallons in 2022 with 21 billion gallons of this to be from advanced biofuels (i.e. "second generation" biofuels).

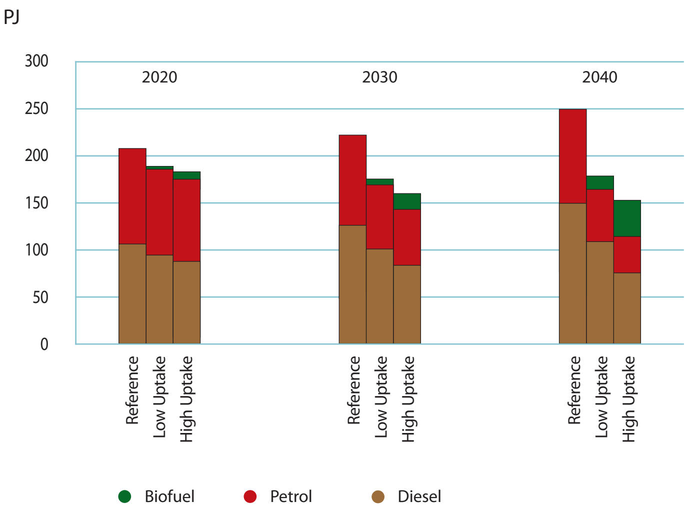
These measures have resulted in recent announcements of demonstration and commercial scale production plants from companies including POET, Du Pont and Coskata. POET, currently the largest ethanol producers in the world, has operated a pilot cellulosic ethanol plant since November 2008 and has recently announced plans to build a 25 million-gallons-per-year cellulosic ethanol plant in Iowa. The plant, which will use corn cobs as feedstock, will be adjacent to POET's grain ethanol plant already in operation on the site.

The modelling has not been prescriptive about the particular form of biofuel produced. It is likely that the biofuel produced will be required to have "drop-in" characteristics, meaning that it will be produced in a form that is fully compatible with the vehicle fleet it finds. Importantly, in the High Uptake case the demand for petrol has been substantially reduced, which will limit the amount of ethanol that might be blended as a replacement fuel.

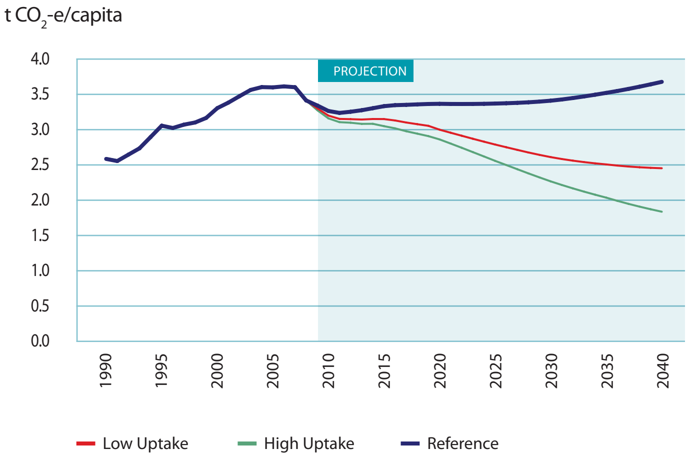
In summary, travel demand reduction, vehicle efficiency gains, uptake of electric vehicles, and biofuels reduce the national demand for oil in 2030 by ~45% and ~25% in the High and Low Uptake cases relative to the *Reference Scenario*.

As a direct consequence of reduced oil demand, this scenario sees a dramatic reduction in per capita transport greenhouse gas emissions which in the High Uptake case are at half 2005 levels by 2040. In these scenarios New Zealand has markedly improved both its energy security and reversed the persistent historical growth in emissions.

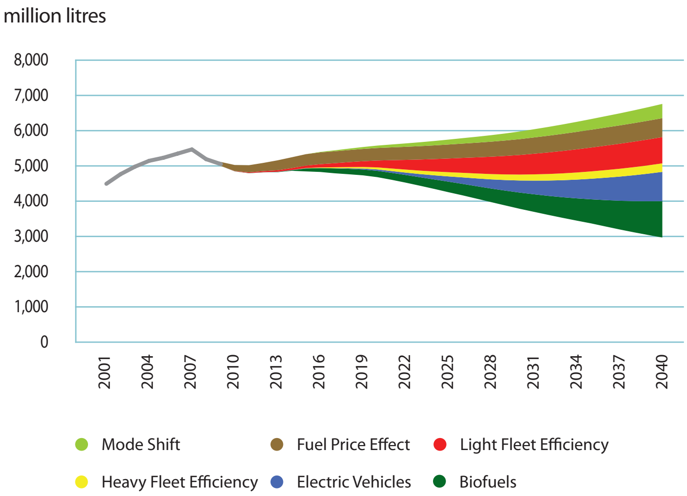
Total Land Transport Demand – Liquid Fuels



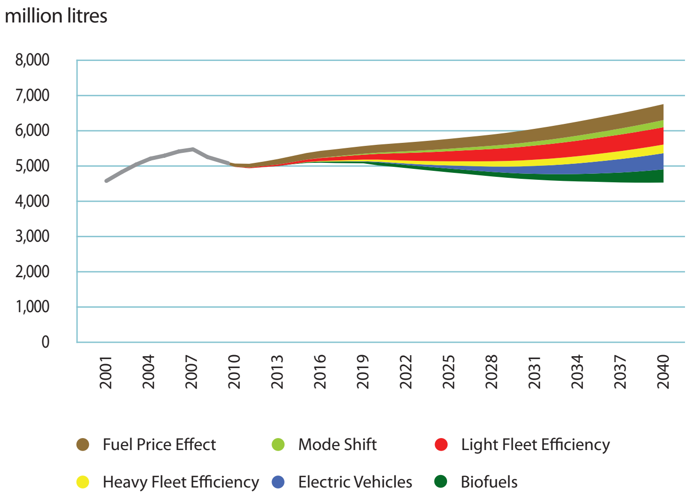
Per Capita Transport Emissions



Liquid Fuel Reduction by Source – High Uptake



Liquid Fuel Reduction by Source - Low Uptake



This scenario also considers the influence of electric vehicles on New Zealand's electricity system. Of particular interest is the effect that re-charging of electric vehicles has on electricity demand, load profile and wholesale prices.

The impact of electric vehicles on electricity demand is minor. For example, even with 35% of the light fleet being electric (as in the High Uptake case) electricity demand is only 5% higher than the *Reference Scenario* in 2040. By this time, at ~2,500GWh per year, electric vehicles make up 4% of total electricity demand.

The increase in electricity demand offsets a considerable amount of petrol demand. This results from the efficiency advantage of the electric vehicles compared with internal combustion engines, where the majority of the energy is lost as waste heat. In terms of petajoules of energy avoided, the electric vehicles in the High Uptake case use ~8PJ of electrical energy while offsetting almost 28PJ of petrol demand in 2040.

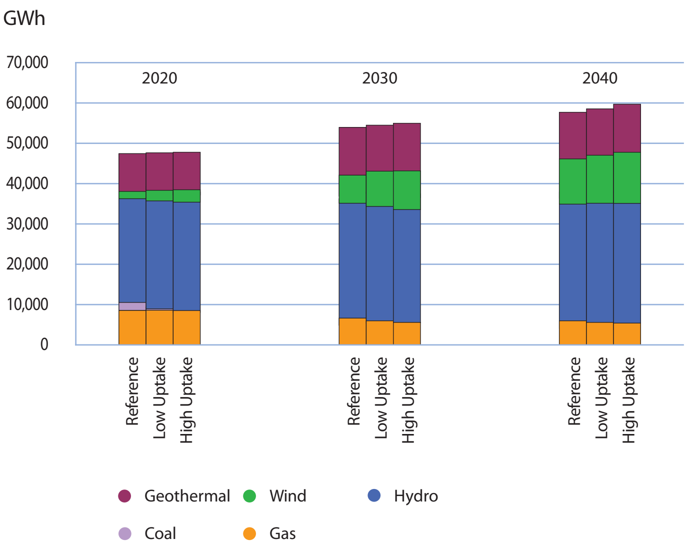
Although the impact of electric vehicle re-charging on electricity energy demand is minor, it still requires more generation capacity to be built. The mix of new baseload and peaking plant needed to meet this demand will depend on the daily pattern of electric vehicle charging. With a flat charging profile – where electric vehicles are assumed to charge evenly throughout the day and night – additional demand can predominately be met through new baseload generation. Under the High Uptake case, ~10% (700MW) additional baseload generation is built by 2040 compared with the *Reference Scenario*.

Increased electricity demand also impacts on wholesale electricity prices. Up until 2020, before the uptake of electric vehicles begins, the higher electricity prices seen in the High and Low Uptake cases (relative to the *Reference Scenario*) are the result of the assumed higher emission prices. Post 2030, electricity prices are ~3% and ~5% higher in the Low and High Uptake cases relative to the *Reference Scenario* due to the additional electricity demand of the electric vehicles.

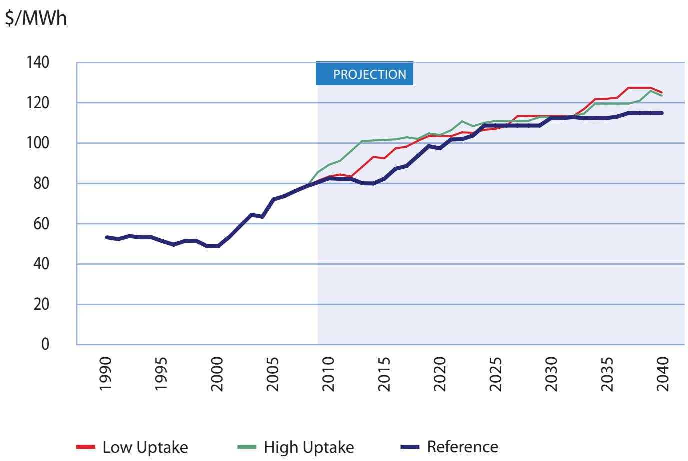
The modelling further explored the relationship between the time of day that vehicle re-charging occurs and the impact on new generation investment, and the wholesale electricity price. When re-charging was concentrated in "peak"[5] periods, an additional ~900MW of new generation was required (compared with ~700MW with a flat profile), of which nearly half was flexible peaking plant. The average wholesale price is much the same as the flat profile, but prices during the peak periods were higher and off–peak prices lower.

Alternatively, with more demand in the off-peak periods, the total new build was very similar to the flat profile, with another ~700MW of new baseload plant. However, the mix of new baseload plant was a little different, with more wind and less hydro. This also resulted in slightly lower wholesale electricity prices. This demonstrates the benefits of managing any new electricity demand away from peak demand periods.

Electricity Generation by Fuel



Wholesale Electricity Prices



[5] Peak periods usually occur around 7am and 5pm on a working day, while off peak periods are typically overnight.

Total Consumer Energy (TCE) is energy used by final consumers. It excludes energy used as a feedstock in methanol and urea production, and for electricity generation.

Both the industrial and commercial sectors use large quantities of fossil fuels to generate heat and to drive industrial processes. These processes include using heat to evaporate the water in milk to produce milk powder, and in the drying of wood products. With the higher fossil fuel prices in this alternative scenario, biomass (i.e. wood) becomes a cost–competitive alternative for heat production. By 2040 biomass makes up ~10% and ~15% of TCE in the Low and High Uptake cases, which compares with the ~7% in the *Reference Scenario*.

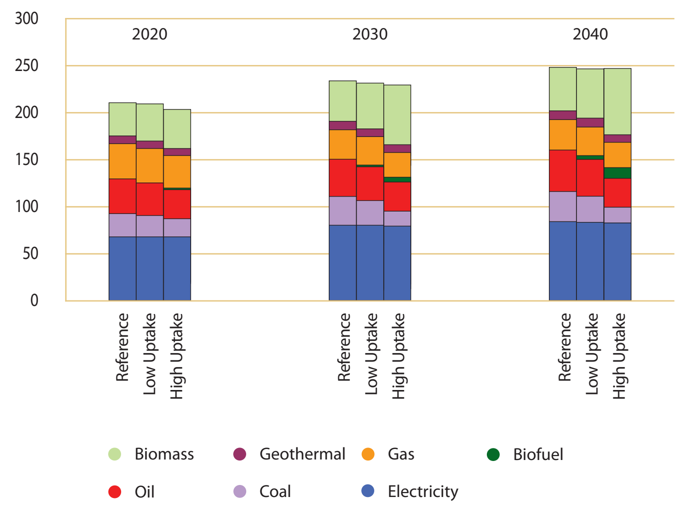
The industrial sector is the greatest user of biomass for heat production and also experiences the greatest increase due to widespread opportunities for replacing coal, natural gas and LPG use with biomass. In the High Uptake case it is assumed that three–quarters of all growth in heat demand is met through the use of biomass. On top of this, up to 25% of existing heat demand is switched to biomass as plant is retired and replaced. The overall result is that by 2040 biomass could make up almost 30% of total industrial energy demand, more than double the 14% share in 2008.

The uptake of biomass for growth in heat demand in this scenario was based on its cost-competitiveness with LPG, natural gas, coal and lignite. This was predominately based on relative fuel cost but was also informed by discussions with interested parties.[6]

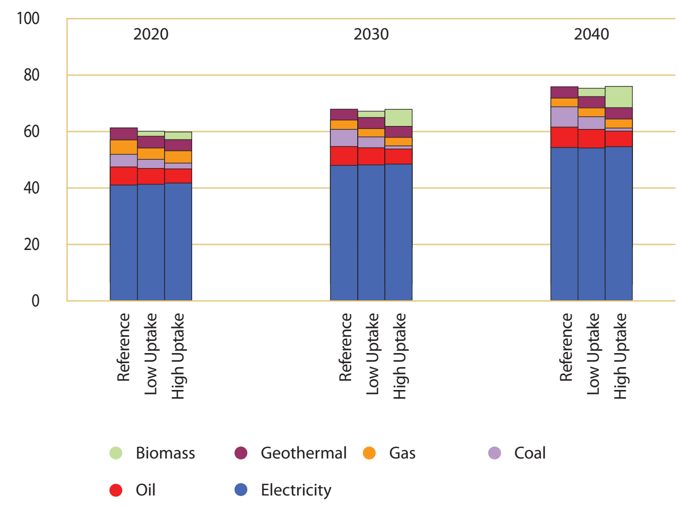
The industrial sector also includes primary industries, such as agriculture, mining, fishing and forestry, where diesel is used to power heavy machinery. In this scenario, biodiesel is expected to replace a portion of mineral diesel consumption. Increasing use of biofuels in these sectors is also likely to be spurred by greater recognition of the lifecycle emissions associated with their products.

Within the commercial and residential sectors the High Uptake case sees a significant proportion of existing LPG and coal heat demand switch to biomass relative to the *Reference Scenario*. Oil products provide only a small share of the energy demand in these sectors and therefore the forecast biofuel consumption within these sectors is very small.

Industrial Energy Demand by Fuel



Commercial Energy Demand by Fuel



[6] The total biomass resource available for both biofuel production and direct use for heat was based on a more conservative interpretation of the theoretical potential presented in Scion's analysis.

Assumptions

www.med.govt.nz/energyoutlook
Email: energyinfo@med.govt.nz

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).

Ministry of Economic Development
Manatū Ōhanga

The *Reference Scenario* assumes oil prices will follow the New York Mercantile Exchange (NYMEX) futures price in the near term, trending towards the International Energy Agency's World Energy Outlook mid-case projection of US$120/bbl (real) by 2030. It also assumes an emissions price of $25/tonne carbon dioxide equivalent. This alternative scenario considers what might happen if fossil fuels become significantly more expensive.

Within this alternative scenario two cases have been included (High and Low Uptake) to better understand the implications for the country's energy system. These cases include the following general assumptions which differ from the *Reference Scenario*:

High Uptake – which assumes:

- a $100/t emissions price post 2012
- international oil prices rising to US$180/bbl by 2030
- light fleet travel demand reduction of 0.25% p.a. from 2015
- heavy fleet travel reduction of 0.4% p.a. from 2015
- light fleet fuel economy improves 25% by 2030
- electric vehicles to a maximum of 50% of new vehicles by 2040
- local production of biofuels rising to 2.5 billion litres by 2050
- switching of 75% of light industry, commercial and residential heat requirement from coal, fuel oil and LPG to biomass
- switching of 75% of the growth in heat requirement in dairy and meat processing and cement production from fossil fuels to biomass
- switching of 2% p.a of existing plant (to a maximum of 25% of existing) in dairy and meat processing and cement production from fossil fuels to biomass.

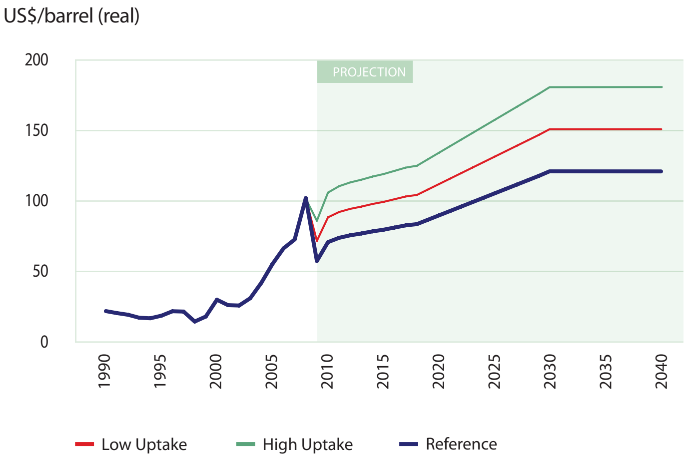
Low Uptake – which assumes:

- a $50/t emissions price post 2012
- international oil prices rising to US$150/bbl by 2030
- light fleet travel demand reduction of 0.125% p.a. from 2015;
- heavy fleet travel reduction of 0.2% p.a. from 2015
- light fleet fuel economy improves 12.5% by 2030
- electric vehicles to a maximum of 25% of new vehicles by 2040
- local production of biofuels rising to 1 billion litres by 2050
- switching of 25% of light industry, commercial and residential heat requirement from coal, fuel oil and LPG to biomass
- switching of 25% of the growth in heat requirement in dairy and meat processing and cement production to biomass.

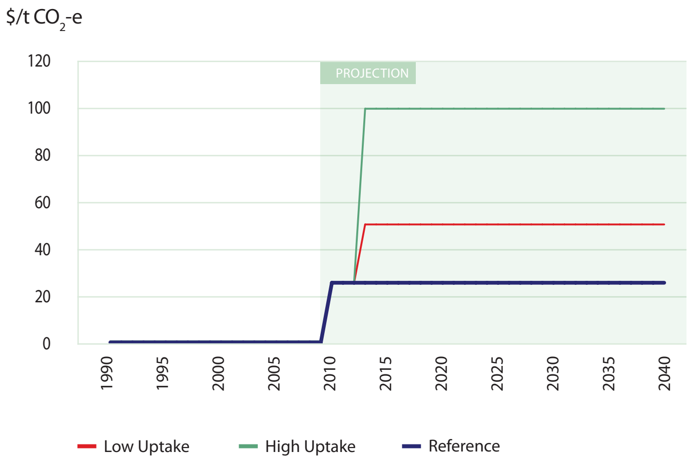
The cost-competiveness and timing of these alternatives fuels and technologies for transport and heat demand are uncertain and in some cases highly speculative. Accordingly, the development of this scenario drew on international research and examples and New Zealand specific case studies. These include Scion's *Bioenergy options for New Zealand – Transition Analysis* and Meridian and Contact Energy's jointly commissioned study *National cost-benefit assessment of the early uptake of electric vehicles in New Zealand.*

The analysis suggests that biofuels from woody biomass become cost-competitive at prices of around $2.15 and $2.50 per litre for diesel and petrol respectively (excl. GST). The maximum penetration of biofuels was informed based on the theoretically available resource in Scion's analysis. From this a draft alternative scenario was developed and refined through discussions with relevant parties including the Ministry of Transport, the Energy Efficiency and Conservation Authority and the Bioenergy Association.

International Oil Price



International Emissions Price



Authorship
This publication was prepared by the Energy Information and Modelling Group of the Ministry of Economic Development. Principal contributors were Mark Dean, Kent Hammond, Simon Lawrence and Mark Walkington.

Layout and design by Origin Design.

ISSN 1179-3996 (print) ISSN 1179-4011 (online)