MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

MARKETS – EVIDENCE AND INSIGHTS BRANCH

ENERGY IN NEW ZEALAND 21

2020 CALENDAR YEAR

Comprehensive information on and analysis of New Zealand's energy supply, demand and prices

Te Kāwanatanga o Aotearoa
New Zealand Government

MINISTRY OF BUSINESS,
INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Ministry of Business, Innovation and Employment (MBIE)

Hīkina Whakatutuki - Lifting to make successful

MBIE develops and delivers policy, services, advice and regulation to support economic growth and the prosperity and wellbeing of New Zealanders.

MBIE combines the former Ministries of Economic Development, Science + Innovation, and the Departments of Labour, and Building and Housing.

Energy in New Zealand 2021 provides annual information on and analysis of New Zealand's energy sector and is part of the suite of publications produced by the Markets team of the Ministry of Business, Innovation & Employment (MBIE).

The 2021 edition includes information up to the end of the calendar year 2020.

Full data tables may be downloaded from the *Energy in New Zealand* webpage:

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*All statistics are year-ending annual measures.

Quick facts for 2020

Energy consumption in the June quarter 2020 was at the lowest quarterly level since the September quarter 1999

Our modern **renewable energy share** is

27.9%

(or 27.9% of our energy demand is **renewable**)

Prior to 2020, national energy consumption was growing an average of ***1.4%*** *per year*

We have enough **gas** reserves to last us until

2030

International Jet fuel consumption down

59%

for 2020 compared to 2019

Combined wind and solar generation reached its **highest ever level.**

Residential energy use was the **highest** it's been since 2009

New Zealand's annual primary energy supply would supply Australia for about

59 days

A: Energy Overview

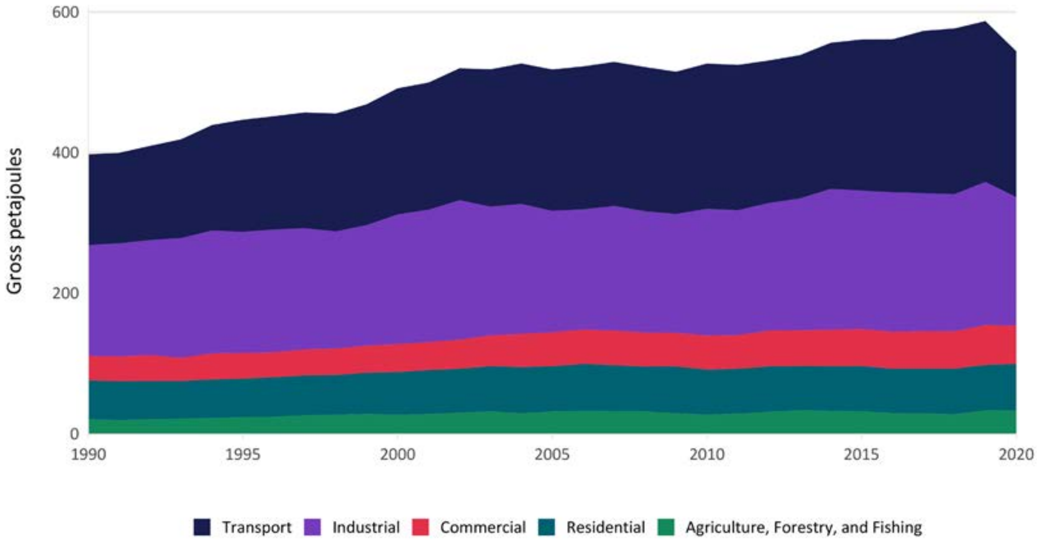
The 2020 calendar year saw disruption to economic activity in New Zealand, with the impacts of the coronavirus (COVID-19) pandemic being felt by the energy sector throughout the year and well into 2021. This saw changes to the supply and demand of energy in New Zealand, with several large energy users citing the pandemic as one of the factors in initiating strategic reviews of their businesses. For more detailed analysis on the impact of the COVID-19 pandemic on the energy sector, see chapter C.

Other developments during the year saw an additional 226 megawatts of electricity generation capacity commissioned. The government also launched several initiatives to help lift households and whānau out of energy hardship, and to support businesses in transitioning to low emissions fuels.

Energy consumption at lowest level in seven years

Restrictions on activities and movement as part of the response to the COVID-19 pandemic impacted global economic activity. This saw national energy consumption fall 7.4 per cent to its lowest level since 2013, with the largest reductions seen in the industrial sector and in transport use. This fall in demand is a contrast to the trend over 1990 to 2019, where sustained increases in energy use for transport led to national energy consumption growing an average of 1.4 per cent per year.

Figure A.1 Energy consumption by sector



After remaining relatively steady in recent years, energy use by the industrial sector fell 10 per cent from 2019 levels as only essential businesses were able to operate under Alert Level 4.[1] While the majority of industrial sector demand recovered following the lifting of these restrictions, some industries saw reduced energy use for the remainder of the year. As a result of the pandemic, New Zealand Aluminium Smelters (NZAS), the country's largest electricity user, closed it's fourth potline (after restarting it in 2018). As at the time of writing, the fourth potline had not been restarted. Production at Pohokura, the country's largest natural gas field, declined relative to 2019. This was after it had returned to near normal production levels in 2019, since it had experienced outages in 2018 (see figure F.21 in the Oil and Gas chapter). These supply constrains at Pohokura saw Methanex (one of the country's largest natural gas users) reduce their activity and therefore energy use.

Restrictions on travel both within and across regions led to lower transport activity. As the majority of energy used for domestic transport in New Zealand is from oil products, this saw demand for oil products fall 8.8 per cent from 2019 levels. The largest reductions were seen in petrol use (down 11 per cent) and use of fuels for domestic aviation (down 31 per cent).

1 Under Alert Level 4, people were required to stay at home unless for essential movement. Travel was also severely limited, with only essential businesses (such as supermarkets and petrol stations) allowed to operate.

Intensity metrics show improvements

Energy intensity provides an indication of the relationship between energy use and economic growth. It is calculated as energy use divided by gross domestic product (GDP) and tells us the amount of energy required to produce each dollar of GDP. A fall in the indicator, where less energy is required to produce each dollar of GDP, is considered an improvement. Energy intensity improved in 2020, with the national average energy intensity indicator falling 4.6 per cent in 2020. Prior to 2020, national average energy intensity had been improving (falling) on an average of 1.4 per cent per annum since 1990. This growth had been driven by continued economic growth in the commercial sector, which is relatively less energy intensive than other parts of the economy as it is service-based.

Stats NZ produces a measure of emissions intensity. This is calculated as greenhouse gas emissions produced by households and businesses divided by GDP, and tells us how many emissions are produced with each unit of output. Like energy intensity, a fall in the indicator (where less emissions are produced per dollar of GDP) is considered an improvement. Over 2007 to 2019, New Zealand's emissions intensity improved on an average of 2.1 per cent per annum.[2,3] This aligns with the trend seen in energy intensity.

COVID impact lowers exports and imports

New Zealand is unable to meet all of its energy needs with domestic production. This can be for a range of reasons, but means that New Zealand has to engage in trade through exporting and importing.

Nearly all of the crude oil produced in New Zealand is exported because it is not suited to our current refining capabilities. This means that all domestic use of oil needs to be met by imports. Reduced transport demand and changes in the mix of transport activity (most significantly lower aviation use) in 2020 reduced the need for the country's only oil refinery at Marsden Point to refine crude oil into oil products. This drove a 15 per cent fall in the import of crude oil and oil products, with the month of July 2020 seeing no crude oil imports for the first time in 34 years. In future there is expected to be a substantial change in the mix of New Zealand's oil imports, with Refining NZ launching a strategic review of its operations in 2020 with a view to ceasing oil refining activities and switching to operating as an import-only terminal.

Under Alert Level 4, mines producing coal for the export market had to temporarily close. This drove a reduction in coal exports in 2020, down 22 per cent from 2019. This fall, alongside lower oil production due to natural decline in existing fields, saw total energy exports fall 24 per cent in 2020, to the lowest level since 1992.

Self-sufficiency is a measure of a country's ability to meet its own energy supply requirements. A self-sufficiency value of 100 per cent indicates that a country produces all the energy it needs, while values above or below indicate whether a country is a net exporter (above) or importer (below) of energy. National average self-sufficiency for New Zealand increased from 75.2 per cent in 2019 to 75.7 per cent in 2020 as a result of lower domestic production.

2 https://www.stats.govt.nz/information-releases/greenhouse-gas-emissions-industry-and-household-year-ended-2019

3 Data is available to 2019 as this is the latest year of data in the New Zealand Greenhouse Gas Inventory.

Share of energy supply from renewable sources hits a high of 40%

Energy supply fell in 2020 as lower domestic consumption reduced the amount of energy needed to meet demand. Primary energy supply of both renewables and non-renewables fell in 2020, with a larger fall seen in the supply of non-renewables. This coupled with lower production of coal and crude oil saw domestic energy production fall to its lowest level since 2007.

Overall the share of renewables in total primary energy supply rose from 39.4 per cent in 2019 to 40.3 per cent in 2020. In this edition of Energy in New Zealand, MBIE has added the share of renewables in total final energy consumption (TFEC) to its suite of energy indicators. The details of measuring the renewable share of TFEC can be found in Box A.1. The share of renewables in TFEC rose from 27.4 per cent in 2019 to 27.9 per cent in 2020.

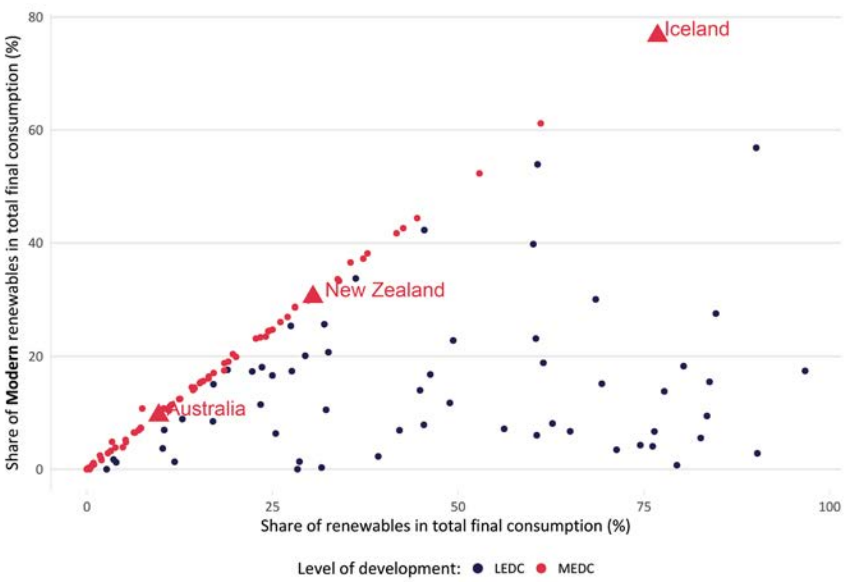
The share of modern renewables in total final consumption

International agencies are now employing a more narrow definition of renewables called 'modern renewables' to aid comparisons across countries. This change does not affect New Zealand's share, though it will affect other countries and hence our relative ranking.

MBIE has added the share of modern renewables in total final energy consumption to its suite of energy indicators in order to provide a more comprehensive view of the use of renewable energy sources across New Zealand's energy system.

When viewed in comparison to international data, this will cause the share of modern renewables for Less Economically Developed Countries (LEDC) to be less than their original share of renewables in total final consumption. For More Economically Developed Countries, their share of modern renewables in total final consumption will remain the same as their original share of renewables in total final consumption. This difference is a result of changing traditional biomass from being a renewable fuel type, to a fossil fuel in LEDC data. This is to aid in international comparisons. You can see the effect of this new indicator on renewable shares below:[4]

Figure A.2 Comparison of different Renewable shares of consumption for different countries in the world



4 This is based off data for 2017 from the IEA and the United Nations. The New Zealand value has been revised to match the 2020 values.

Box A.1

Measuring the share of modern renewables in total final consumption

There are three indicators that are often used for measuring the renewable share of energy:

› Renewable share of total primary energy supply (TPES), which tells us the share of energy available for use in New Zealand that is from renewable sources
› Renewable share of electricity generation, which tells us the share of electricity that is generated from renewable sources
› Share of renewables in total final energy consumption (TFEC), which tells us the share of energy consumed by end-users (such as businesses and households) that is from renewable sources

The first two measures, looking at TPES and electricity generation, are most commonly used internationally as they are relatively easy to measure due to their focus on the supply-side. They are also internationally comparable, meaning that we can easily compare the shares for New Zealand with other countries.

However there are some drawbacks with using a renewable share of TPES and these drawbacks can have opposite effects on the measure. Most notably:

› The conversion efficiency of geothermal energy to electricity is relatively low. This will lead to a renewable share based on TPES overstating the true extent of renewable energy available for use in an economy, as a relatively low amount of this geothermal energy is ultimately converted to useful energy.
› TPES includes use of non-energy use of fossil fuels. 'Non-energy use' refers to use of fuels for purposes other than combustion, such as the use of natural gas as a chemical feedstock in in the production of methanol and ammonia/urea. The inclusion of supply of fuels to non-energy use in TPES will overstate the use of non-renewable fuels in an economy, reducing the renewable share of TPES.

Conversely, there is value in considering a TPES measure as the inclusion of non-energy use of fossil fuels shows that there are competing uses for New Zealand's energy supply. For example, natural gas could be used for electricity generation, by businesses for their production processes (such as drying milk powder), or as a feedstock for methanol production.

In recent years, there has been a growing focus on increasing the use of renewable energy sources, as seen with the United Nation's Sustainable Development Goals (SDG).[5] SDG Goal 7 to 'ensure access to affordable, reliable, sustainable and modern energy for all' has a target to increase the share of renewable energy globally by 2030.   The United Nations has chosen the renewable share of TFEC to be the progress indicator for to this target, rather than a TPES based measure.

Renewable energy can be classified as 'modern' or 'traditional'. 'Traditional biomass' refers to the use of these energy types for heating and cooking by households in developing countries, while 'modern renewables' is total renewable energy use less any traditional biomass use. The wide use of traditional biomass can lead to some developing countries having a renewable share of TFEC that is close to 100 per cent, far higher than any developed country.

As such, a common approach is to consider the share of 'modern renewables' in TFEC, rather than the share of all renewables, in order to account for the differences in the circumstances

5 https://sdgs.un.org/goals

in individual countries and to support international comparability. For developed countries, all biomass use is assumed to be 'modern', while for developing countries only the portion of energy use that is not used by households is considered to be 'modern.'

MBIE has added the share of modern renewables in TFEC to its suite of energy indicators in order to provide a more comprehensive view of the use of renewable energy sources across New Zealand's energy system. In 2020 the value was 27.9 per cent. This indicator is calculated as:

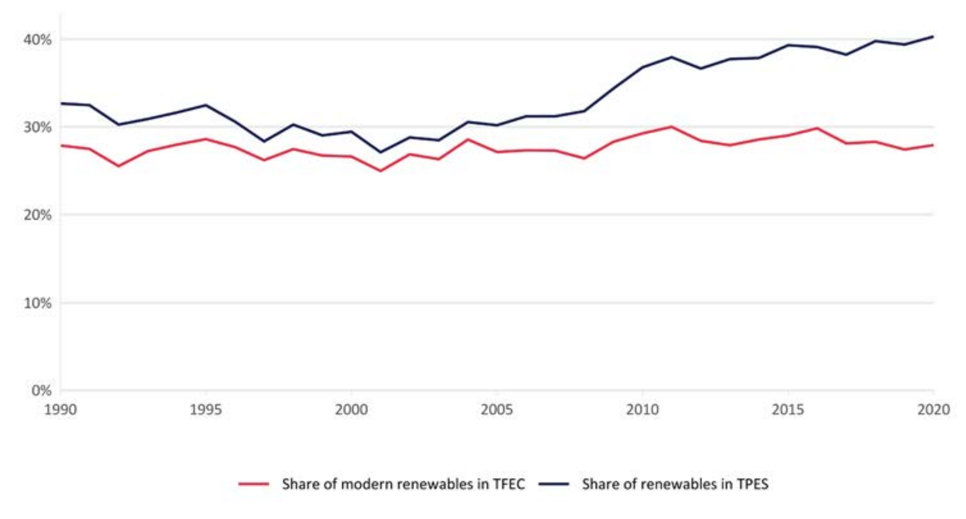
$$\textit{Share of modern renewables in TFEC} = \frac{\textit{(Direct use of modern renewables+Electricity use allocated to renewables)}}{\textit{(Total TFEC)}}$$

where:

- Direct use of modern renewables is the use of modern renewable energy by end-users without it first going through a transformation process (e.g. electricity generation), such as using geothermal energy for heating greenhouses.
- Electricity use allocated to renewables is calculated by applying the renewable electricity generation share to final consumption of electricity, to give an estimate of the amount of electricity consumed that is from renewable sources

Prior to 2005, the share of modern renewables in TFEC and the renewable share of TPES tracked closely together. Since then, the use of geothermal for baseload electricity generation has grown. With a relatively low conversion efficiency of geothermal energy to electricity, this has contributed to the growth in renewable TPES, without similar growth in TFEC. This has resulted in the two measures diverging in recent years, with a 12.4percentage point difference between the two measures in 2020.

Box A.1 Figure 1 Comparison of renewable share measures



It is important to note that a renewable share of TFEC indicator does not account for electricity losses. The renewable electricity generation share is calculated as at the point of generation and is applied to consumption of electricity on the assumption that the mix stays the same across all use. That is, it is calculated before the electricity has been conveyed on the national grid and/or local distribution networks to end-users (eg. businesses and households). Losses occur in the process of conveying electricity from the point of generation to end-users due to a range of factors, such as the length and size of power lines. In 2020, transmission and distribution losses in New Zealand accounted for 6.9 per cent of electricity supply. The existence of these losses means that the mix of electricity reaching end-users will not match what is entering the system. In constructing the renewable share of TFEC as outlined above, the assumption is made that mix of electricity stays the same throughout the system and across all use.

B: Energy balances

New Zealand's energy production derives from both renewable and non-renewable sources. New Zealand imports and exports fossil fuels, which generate export revenue, but also results in a dependency and vulnerability to energy commodity prices that vary according to international supply and demand factors outside of New Zealand's control.

The energy balance tables reflect how energy supply and demand by sector varies by energy fuel type. Domestic energy supply is derived from either indigenous production or imported from overseas sources. In turn, fuel types can be transformed into different forms of energy, at the cost of losses and inefficiencies which vary by transformation process. Supply, demand, losses and inefficiencies are reflected in balanced energy supply and demand tables.

Both the energy supply and demand dimensions of the energy balance tables are derived from surveys spanning different sources. An imbalance exists between the value of consumer energy calculated from supply, and the value of consumer energy observed from statistical measure.

Interpretation of Energy Balance Tables

Supply

Total primary energy is the amount of energy available for use in New Zealand. Much of it is converted into other forms of energy before it is used. By convention, fuel used for international transport is excluded from total primary energy. Indigenous gas production does not include gas that is flared, reinjected, or LPG extracted. The primary energy figures presented are actual data, except for some that go into electricity generation as detailed under energy transformation.

Energy transformation

Includes generation of electricity (including cogeneration), oil production (including refinery operations and the manufacture of synthetic fuel from natural gas – Methanex ceased methanol to petrol production in April 1999) and other transformation, primarily steel production.

Table B.1 Default Electrical Transformation Factors[6]

Fuel	Default Efficiency
Biogas	30%
Coal	30%
Gas (Single Cycle)	30%
Geothermal	15%
Hydro	100%
Oil	30%
Waste Heat	15%
Wind	100%
Wood	25%

In the Energy Transformation section of the balance tables, "energy in" is shown as negative values and "energy out" as positive values in the appropriate fuel columns. Transformation of energy from one form to another always results in conversion losses, particularly in thermal electricity generation, as much energy is lost as heat.

Transformation losses in electricity generation are derived from the net electricity generated, with the actual fuel input being used where available and the conversion factors shown in Table B.1 used otherwise. Fuel input to biogas, hydro, wind and waste heat are fully estimated. Quarterly figures for electricity generation are made up of actual data from major generators and the Electricity Authority. Estimates are made where actual data are unavailable at the time of publishing.

Liquid biofuel production (bioethanol and biodiesel) appears as renewable energy supply in the energy balance tables. As bioethanol and biodiesel are generally blended with motor petrol and diesel before consumption, liquid biofuel also appears in Energy Transformation under Fuel Production.

Losses and own use in the energy balances include losses before and after transformation, losses and own use in production, transmission and distribution losses, electricity industry own use free of charge, and oil industry losses and own use (which includes distribution tankage losses, stocks, accounts adjustment and own consumption). Transformation losses are excluded.

Non-energy use is primary energy used for purposes other than combustion, e.g. bitumen used in road construction, and natural gas used as chemical feedstock in the production of methanol and ammonia/urea.

6 a) Default efficiencies are only used where real data is unavailable. b) For combined cycle plants, the assumed efficiency is 55%. Currently, however, actual fuel input data are collected for all combined cycle plants.
c) Geothermal is predominantly based on real plant steam data and uses a 15% efficiency where these are unavailable

Treatment of Solar Photovoltaic Panels

Estimates of the amount of electricity generated using solar photovoltaics (PV) are included in the energy balance tables in this edition of Energy in New Zealand. The total primary energy supply of solar is the sum of the direct use of solar thermal (i.e. for hot water heating), and the amount of solar energy directly converted into electricity via PV panels. Solar PV electricity generation is estimated using data on the total installed capacity of grid-connected solar PV installations in New Zealand , and then converted to output using an assumed annual capacity factor of 14% (i.e. the solar panels produce their full output 14% of the time). The capacity factor is then scaled using solar-hour data from NIWA to introduce seasonal variation. Consumption of solar thermal is included in the demand section of the energy balance table under Renewables – Solar, whereas the consumption of electricity generated by solar PV panels appears under Electricity. Solar PV consumption by sector is apportioned using data from the Electricity Authority.

Demand

Consumer energy is the amount of energy consumed by final users. It excludes energy used or lost in the process of transforming energy into other forms and in bringing the energy to the final consumers. For example, natural gas is a primary energy source (see Total Primary Energy Supply), some of which is transformed into electricity, of which some is lost in transmission to consumers.

Consumer energy statistics can be either calculated from supply-side data or observed from usage data.

Consumer energy (calculated) forms the top half of the energy balance tables and is calculated as TPES less energy transformation less non-energy use.

Consumer energy (observed) forms the bottom half of the energy balance tables and it represents reported demand in the agriculture, forestry and fishing; industrial; commercial; transport and residential sectors. With the exception of domestic/national use of energy for on-road, rail, sea and air transport in the transport sector, these sectors follow the Australia New Zealand Standard Industrial Classification 2006 definitions.

Annual figures presented for consumer energy (observed) are actual data except for thermal fuels used for cogeneration in the industrial and commercial sectors and biogas, wastes and wood. Estimates of on-site cogeneration demand are included in electricity end use.

Where the energy end-use is not available or confidential, the “unallocated” category is used.

International transport includes international sea and air transport. It excludes coastal shipping, national air transport and all land transport.

Statistical differences shows the difference between “consumer energy (calculated)” and “consumer energy (observed)”. This difference is shown at the bottom of the energy balance tables.

Energy Supply and Demand

Calendar Year

2020

Converted into Petajolues using Gross Calorific Values	Coal: Bituminous	Coal: Sub-bitum.	Coal: Bituminous & Sub-bitum.	Coal: Lignite	Coal: **Total**	Oil: Crudes/ Feedstocks/ NGL	Oil: LPG	Oil: Petrol	Oil: Diesel	Oil: Fuel Oil	Oil: Av. Fuel/ Kero	Oil: Others
SUPPLY												
Indigenous Production	34.06	33.85	67.91	5.40	**73.31**	44.80	8.21					
+ Imports	1.18	25.27	26.45	0.00	**26.46**	183.28	0.79	45.20	58.77	0.95	4.69	12.90
- Exports	33.45	0.79	34.24		**34.24**	41.83						
- Stock Change	- 0.18	4.96	4.77	0.01	**4.78**	8.85	(0.05)	0.88	(0.46)	(0.68)	0.85	0.41
- International Transport					**0.00**			0.00	5.37	2.42	23.00	
TOTAL PRIMARY ENERGY	**1.98**	**53.37**	**55.35**	**5.39**	**60.75**	**177.39**	**9.05**	**44.32**	**53.86**	**(0.79)**	**(19.16)**	**12.49**
ENERGY TRANSFORMATION	**- 0.13**	**- 37.22**	**(37.35)**	**(0.14)**	**(37.49)**	**(178.04)**	**0.00**	**57.64**	**77.27**	**7.08**	**29.48**	**3.96**
Electricity Generation		- 19.42	(19.42)		**(19.42)**				(1.43)			
Cogeneration		- 7.36	(7.36)	(0.13)	**(7.49)**							
Fuel Production					**0.00**	(178.04)		54.99	78.36	6.48	29.29	6.32
Other Transformation		- 10.13	(10.13)		**(10.13)**							
Losses and Own Use	- 0.13	- 0.31	(0.43)	(0.02)	**(0.45)**			2.65	0.34	0.61	0.19	(2.36)
Non-energy Use												**(14.65)**
CONSUMER ENERGY (calculated)	**1.86**	**16.15**	**18.01**	**5.25**	**23.26**	**(0.65)**	**9.05**	**101.96**	**131.13**	**6.29**	**10.31**	**1.80**
DEMAND												
Agriculture, Forestry and Fishing	**0.05**	**1.82**	**1.87**	**0.00**	**1.87**		**0.11**	**1.64**	**17.11**	**0.80**	**0.00**	
Agriculture	0.05	1.82	1.87	0.00	1.87		0.11	1.56	12.77			
Forestry and Logging			0.00		0.00			0.01	1.97			
Fishing			0.00		0.00			0.07	2.36	0.80		
Industrial	**2.08**	**13.93**	**16.01**	**5.09**	**21.10**		**3.58**	**0.10**	**16.22**	**0.64**	**0.00**	
Mining			0.00		0.00			0.00	5.26			
Food Processing	0.34	12.94	13.29	5.01	18.30							
Textiles	0.11	0.05	0.16		0.16							
Wood, Pulp, Paper and Printing	0.05	0.20	0.25	0.00	0.25							
Chemicals		0.02	0.02		0.02							
Non-metallic Minerals	1.18	0.71	1.90	0.08	1.98							
Basic Metals			0.00		0.00							
Mechanical/Electrical Equipment			0.00		0.00							
Building and Construction			0.00		0.00			0.01	6.42			
Unallocated	0.40		0.40		0.40		3.58	0.09	4.54	0.64		
Commercial	**0.09**	**0.44**	**0.53**	**0.10**	**0.63**		**1.70**	**1.12**	**5.90**	**1.67**		
Transport			**0.00**		**0.00**		**0.13**	**97.86**	**95.11**	**3.72**	**10.31**	
Residential	**0.01**	**0.26**	**0.27**	**0.04**	**0.31**		**3.63**	**0.00**	**0.10**			
CONSUMER ENERGY (observed)	**2.24**	**16.44**	**18.68**	**5.23**	**23.91**	**0.00**	**9.15**	**100.71**	**134.44**	**6.83**	**10.31**	**0.00**
Statistical Differences			**(0.67)**	**0.02**	**(0.65)**	**(0.65)**	**(0.09)**	**1.25**	**(3.31)**	**(0.54)**	**(0.00)**	**1.80**

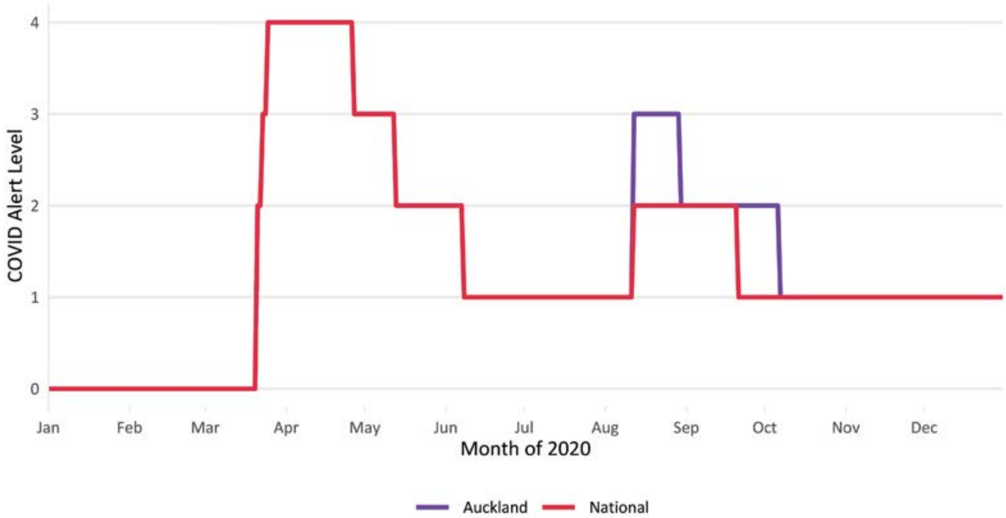
	Natural Gas	Renewables								Electricity	Waste Heat	TOTAL
Total	Total	Hydro	Geothermal	Solar	Wind	Liquid Biofuels	Biogas	Solid Biofuels	Total	Total	Total	
53.01	180.17	87.36	200.69	0.94	8.30	0.32	3.80	48.66	350.06		1.02	657.57
306.59								0.10	0.10			333.14
41.83									0.00			76.07
9.80	0.58								0.00			15.17
30.80									0.00			30.80
277.17	179.59	87.36	200.69	0.94	8.30	0.32	3.80	48.76	350.16		1.02	868.68
(2.60)	(59.59)	(87.36)	(192.92)	(0.57)	(8.30)	(0.32)	(3.49)	(21.57)	(314.52)	144.26	(1.02)	(270.97)
(1.43)	(41.19)	(87.36)	(191.51)	(0.57)	(8.30)		(2.68)		(290.42)	151.79		(200.67)
0.00	(12.62)		(1.41)				(0.80)	(21.57)	(23.78)	7.99	(1.02)	(36.92)
(2.60)						(0.32)			(0.32)			(2.92)
0.00									0.00			(10.13)
1.43	(5.78)								0.00	(15.52)		(20.33)
(14.65)	(46.23)											(60.88)
259.91	73.76		7.77	0.36	0.00	0.00	0.31	27.19	35.64	144.26	0.00	536.82
19.66	1.42		0.45						0.45	9.67		33.06
14.45	1.42		0.45						0.45	9.27		27.45
1.98	0.00								0.00	0.24		2.21
3.23									0.00	0.16		3.40
20.54	60.67		4.74				0.05	19.65	24.44	52.56		179.32
5.26	0.17								0.00	1.50		6.93
0.00	19.73								0.00	10.34		48.37
0.00	0.41								0.00	0.34		0.91
0.00	4.61							19.65	19.65	7.50		32.02
0.00	31.56								0.00	2.75		34.33
0.00	0.87								0.00	0.94		3.79
0.00	2.52								0.00	22.46		24.98
0.00	0.27								0.00	0.50		0.77
6.44	0.38								0.00	1.41		8.22
8.84	0.16		4.74				0.05		4.79	4.81		19.00
10.39	7.88		2.38				0.26		2.64	33.03		54.57
207.13									0.00	0.36		207.49
3.73	7.20		0.21	0.36				7.54	8.11	46.36		65.71
261.45	77.16	0.00	7.77	0.36	0.00		0.31	27.19	35.64	141.99	0.00	540.14
(1.54)	(3.40)		0.00	0.00	0.00		(0.00)	0.00	0.00	2.27	0.00	(3.32)

C: Impacts of COVID-19

On 30th January 2020, the World Health Organisation declared a Public Health Emergency of International Concern over the outbreak of a novel coronavirus (COVID-19). On February 28th, 2020, the first case of COVID-19 was detected in New Zealand. This led to the New Zealand Government establishing the COVID-19 Alert System on 21st March 2020, followed by the alert level being increased to Level 4 on 23rd March, 2020. For the remainder of the year, New Zealand moved between Alert Levels 1 through 4, as the risk of community transmission changed.

It is impossible to look at energy use in New Zealand in 2020 without considering the effect COVID-19 had on New Zealand's society and economy. This section considers the larger effects the pandemic had on energy supply and demand in New Zealand.

Figure C.1 COVID Alert Levels 2020



Box C.1

Box F.1: Other notable events of 2020

While COVID-19 may have been the largest single news story of 2020, there were other major events in New Zealand that impacted energy production and consumption that might interest you.

Here are some of the major events you can read about in other chapters:

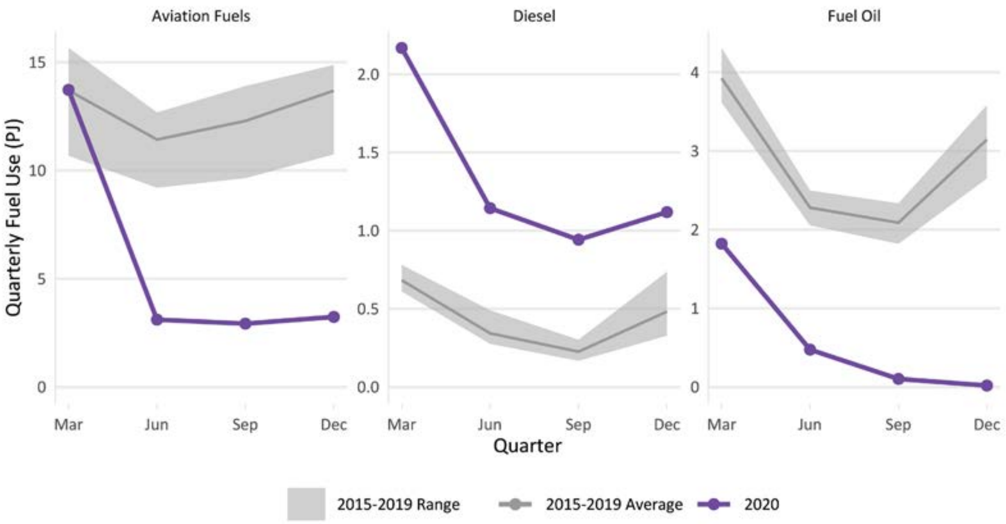
› In Electricity: Several new electricity plants were commissioned, while others were delayed due to COVID-19.

› In Oil and Gas: Refining NZ announced a strategic review of the Marsden Point oil refinery.

› In Renewables: Developments within the renewable energy space, including projects and announcements related to hydrogen, biofuels, solar and super-critical geothermal

Transport consumption dropped sharply

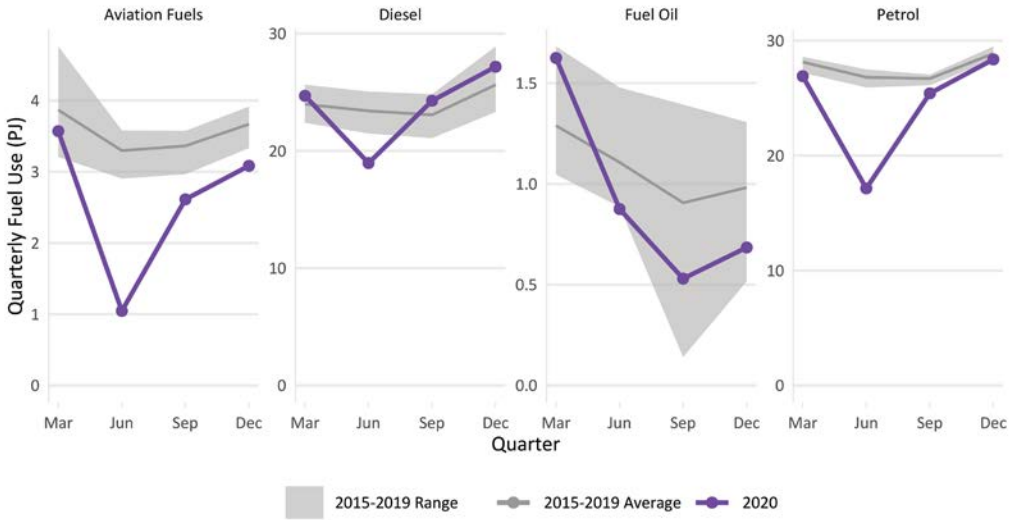
Figure C.2: Fuel Consumption for International Transport



Energy used for international transport fell by 39.6 PJ (56 per cent) in 2020. The largest percentage drop in international transport use prior to 2020 was a 19 per cent drop in 1980, following the 1979 Oil Crisis. The bulk of the drop occurred in the June quarter 2020, where total use fell by 10.5 PJ on June 2019 (69 per cent). This is consistent with the implementation of the alert level system, fuels used by aviation dropped more than marine transport. Aviation fuels fell by 33.5 PJ (59 per cent) in 2020, while marine fuels (diesel and fuel oil) fell by 6.1 PJ (44 per cent) in the same period. Note that diesel used in marine transportation actually increased by 3.5 PJ (182 per cent) compared to 2020, suggesting that diesel was being substituted for fuel oil. The substitution between fuels may be COVID-19 related, but is also likely to be a result of the new MARPOL Annex VI rules for international shipping.[7]

7 Effective 1 January 2020, the maximum sulphur content for fuel oil in shipping was lowered to 0.5% from 3.5%. While New Zealand is not yet a signatory to this requirement (the relevant legislation is being considered by Select Committee at time of publication), the regulations apply based on where a ship is registered, meaning that ships visiting New Zealand would be affected if they were registered with a signatory country.

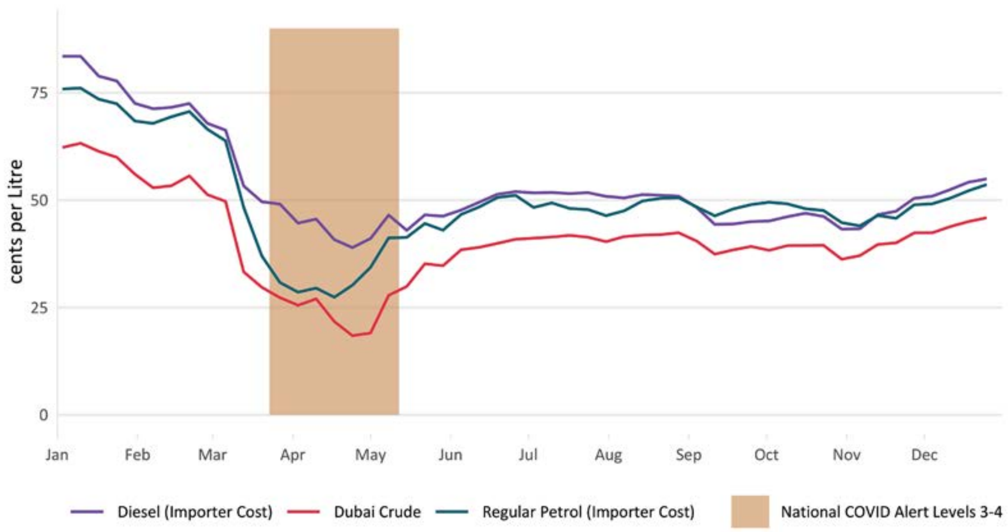
Figure C.3 Fuel Consumption for Domestic Transport



The fall in domestic transport fuel use was not as large, though still unprecedented. Across all fuels, domestic transport use fell 21 PJ (9.4 per cent). The largest previous percentage drop in domestic transport use since 1990 was a 2.5 per cent reduction in 2012. Among all fuel types, the largest percentage fall was seen in aviation fuels (31 per cent), followed by fuel oil (17 per cent) and petrol (12 per cent). For most fuels, the quarter with the sharpest decrease was June, in line with the period with the highest alert level. A notable exception is fuel oil, which fell more sharply in the year ending September (46 per cent) than the year ending June (22 per cent). These decreases in fuel oil are matched by increases in diesel use in the September and December quarters, which suggests there may have been substitution between fuel oil and diesel, though the variability in fuel oil consumption makes this less clear than for international transport.

Falling global oil demand led to lower retail prices

Figure C.4 Fuel Importer Cost 2020



In early 2020, crude oil prices had already started to fall due to geopolitical factors (the Dubai Crude[8] price fell 25 per cent between January 3rd and March 6th 2020), but the drop in price became even more pronounced in early March as many countries started implementing travel and business restrictions in response to COVID-19. This led to a global reduction in oil demand, and the Dubai Crude Price fell another 65 per cent between March 6th and April 24th 2020, when it reached its lowest point of USD 17.55 per barrel.

One factor slightly offsetting some of the fall in international crude prices, was higher shipping rates for importing crude to New Zealand. As international demand plummeted, refinery activity dwindled and inventories of product soared. Some tankers were simply converted to floating storage vessels and this saw shipping rates climb dramatically for a short spell.

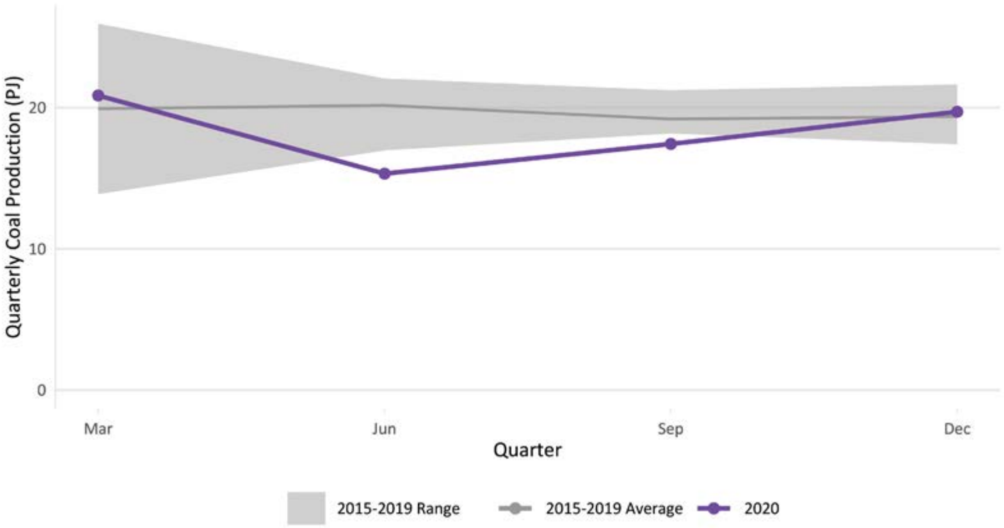
Domestic demand for crude fell during this period as well, sharply enough that Z Energy cancelled a crude oil tanker due to reduced production at the refinery.

Importer costs for petrol and diesel followed a similar trend as the falling international demand and cheap crude made these products cheaper to buy. Regular petrol importer costs fell from $0.76/L at the start of 2020, to a low of $0.27/L in mid-April. While importer costs increased over the course of the year, they did not return to March 2020 levels during the year.

Importer costs for diesel over 2020 were less impacted, but followed a similar course, falling from $0.84/L on January 3rd 2020 to a low of $0.39/L on April 24th.

Coal production was disrupted by heightened alert levels

Figure C.5 Coal Production



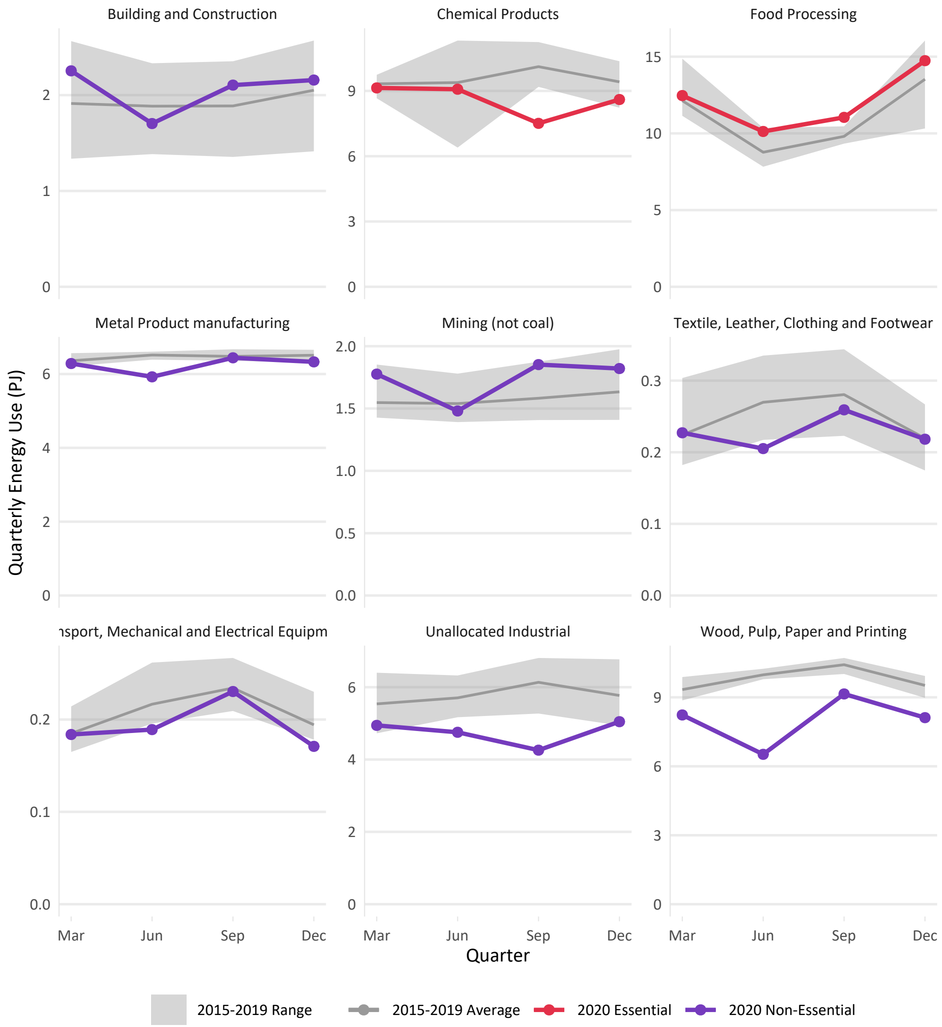
Coal production for export was not categorised as an essential activity under Alert Levels 3 and 4. COVID-19 mitigation measures under Alert Level 2 for export coal and alert levels 2, 3 and 4 for domestic production acted as an impediment to production. This, combined with the difficulty of finding export ships during the pandemic, led to coal production being much lower during the June and September quarters than the same quarters in the preceding five years. Coal production fell 23 per cent over the year ending June 2020, and 10 per cent over the year ending September 2020. Production only fell 2 per cent over the year ending December 2020, indicating that coal production had largely returned to trend by the end of the year.

The drop in production also affected exports – coal exports fell 23 per cent and 12 per cent in the years ending June and September 2020, respectively.

8 Historically, New Zealand has imported most of its crude oil from the Middle East. This means that the Dubai Crude price is a better reflection of importing crude to New Zealand than a European crude price like the Brent Oil price.

Essential industry status affected industrial energy use

Figure C.6 Industrial energy use



The main driver of whether COVID-19 affected energy use for each industrial sector was dependent on whether the industry had much of its activity classified as essential or not.

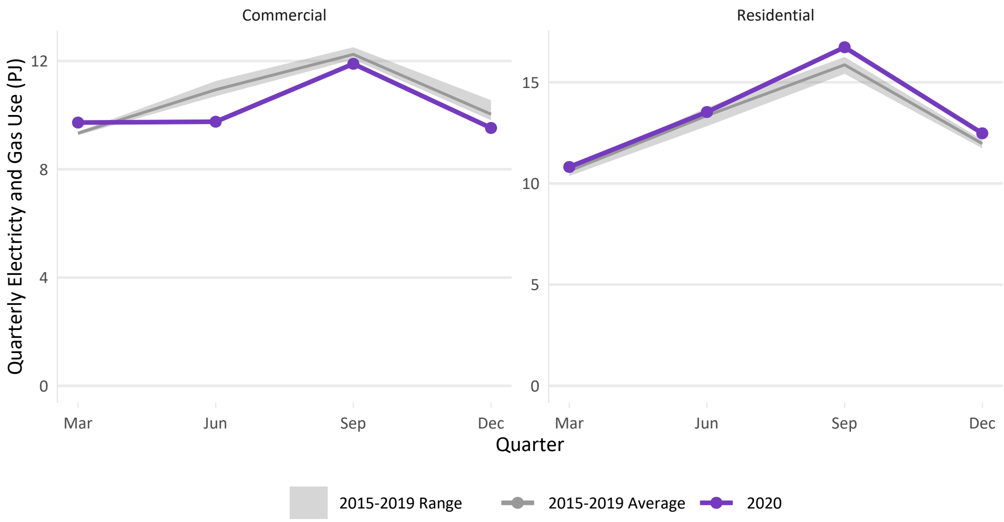
Non-essential industries show a substantial annual decrease in consumption in the June quarter 2020, typically followed by lesser annual decreases in September and December 2020. Industries that exhibited this reduced fuel use pattern included (for year ending June 2020):

- Textiles and Clothing (39 per cent)
- Wood, Pulp, Paper and Printing (34 per cent)
- Building and Construction (27 per cent)
- Mining (17 per cent)
- Metal Product Manufacturing (10 per cent)
- Unallocated Industrial (8.0 per cent), though this category dropped more sharply in September 2020.

By contrast, the Chemical and Food Processing industries did not exhibit this pattern – as these industries contained a significant number of essential businesses, their activity was not affected by the Alert Level.

People staying at home increased residential energy consumption

Figure C.7 Commercial and Residential Electricity and Gas use



The COVID-19 alert level restrictions were most stringent in the June quarter, with the September quarter being the second-most stringent. More than 40 percent of employed people did at least some of their work from home during the lockdown at COVID-19 alert Levels 4 and 3 in April and early May.[9]

This effect can be seen in the energy consumption patterns of natural gas and electricity, the two largest energy sources for commercial use. While the March 2020 quarter showed residential and commercial consumption in line with a normal March quarter, subsequent quarters showed higher than normal residential consumption balanced by lower than usual commercial consumption. Commercial electricity and gas consumption fell by 1.9 PJ (4.4 per cent) from 2019 to 2020, while residential consumption increased by 1.2 PJ (2.3 per cent). It is unusual for commercial and residential electricity and gas consumption to move in opposite directions, especially by more than 1 per cent. The last time that residential use increased by more than 1 percent and commercial fell by more than 1 per cent (or vice versa) was 2005.

9 https://www.stats.govt.nz/news/four-in-10-employed-new-zealanders-work-from-home-during-lockdown

Box C.2 Other Sources of COVID-19 Information

There are a number of sources outside this chapter that can provide additional information on energy as it relates to COVID-19:

- The other chapters in Energy in New Zealand will provide additional insights for those energy types.
- MBIE's Energy Statistics and Modelling[10] provides a range of energy data on a quarterly, monthly or even weekly basis, providing the latest information on energy production, transformation and consumption.
- Statistics New Zealand also produces a range of high-frequency economic data in their COVID-19 Data Portal.[11] Data on international and domestic travel, electricity demand and gas consumption may be of particular interest.

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10 https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/

11 https://www.stats.govt.nz/experimental/covid-19-data-portal

D: Electricity

Supply

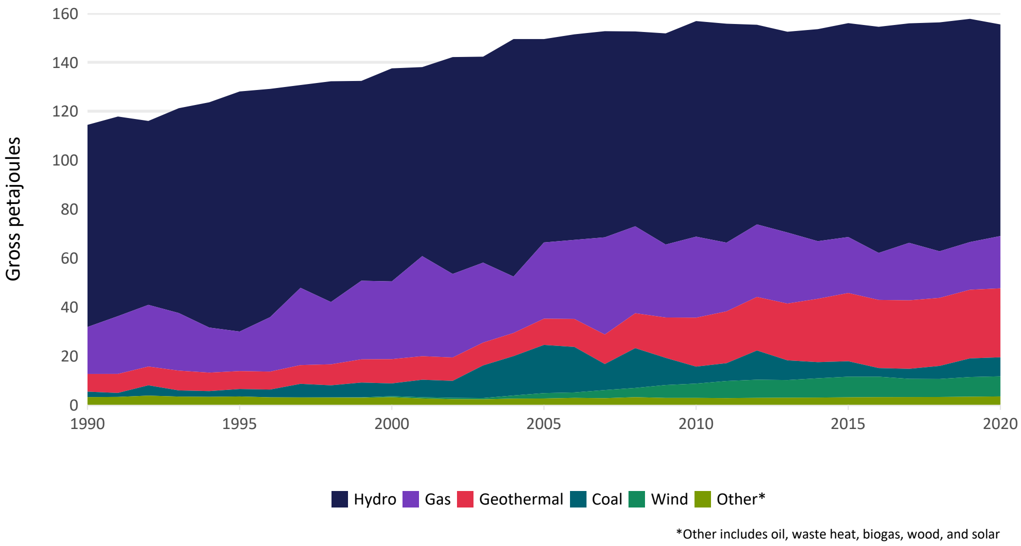
Low hydro lake inflows led to a drop in renewable generation

Electricity generation was 1.4 per cent lower than in 2019. This is the first fall in electricity generation since 2016.

The share of renewable's in generation fell to 81.1 per cent. This is mainly due to a decline in hydro generation, which is largely dependent on hydro lake inflows. Hydro lake storage and lake inflows started off high at the start of the year, with hydro storage exceeding nominal full levels due to higher than normal rainfall in the South Island hydro catchments.

Subsequently, there was a warm and dry spell across most of the country. The warm and dry weather continued into the winter season. With below normal rainfall, hydro lake inflows fell below historical average for most of autumn and winter. This led to annual hydro generation dropping by 5.2 per cent.

Figure D.1 Electricity generation by type



Electricity generated from wind increased

2020 saw the commissioning of Waipipi wind farm, which started injecting to the grid in November. Generation from wind increased by 2.2 per cent compared to 2019. The capacity factor[12] for wind generation also increased to 37 per cent, slightly higher than the year before. This increase in capacity factor accounts for the increase in generation capacity. This suggests that wind conditions in 2020 was favourable for electricity generation. The September quarter of 2020 saw the highest ever generation from wind for a September quarter, exceeding 600 GWh.

Electricity generated from natural gas increased despite declining production at Pohokura gas field

There was an increased reliance on fossil fuels as renewable generation was lower than the previous year. Electricity generated from natural gas and coal increased by 9.6 per cent and 1.9 per cent respectively, to make up for lowered renewable generation.

Production at Pohokura, New Zealand's largest natural gas field, declined in 2020. Production from the Pohokura gas field stopped for a maintenance outage in March and production was subsequently affected when natural gas demand fell during COVID-19 Alert Levels 3 and 4.[13] As a result of the drop

12 Capacity factors tell us how much electricity was generated by a source over a period of time relative to the maximum amount that could have been generated based on its installed capacity.

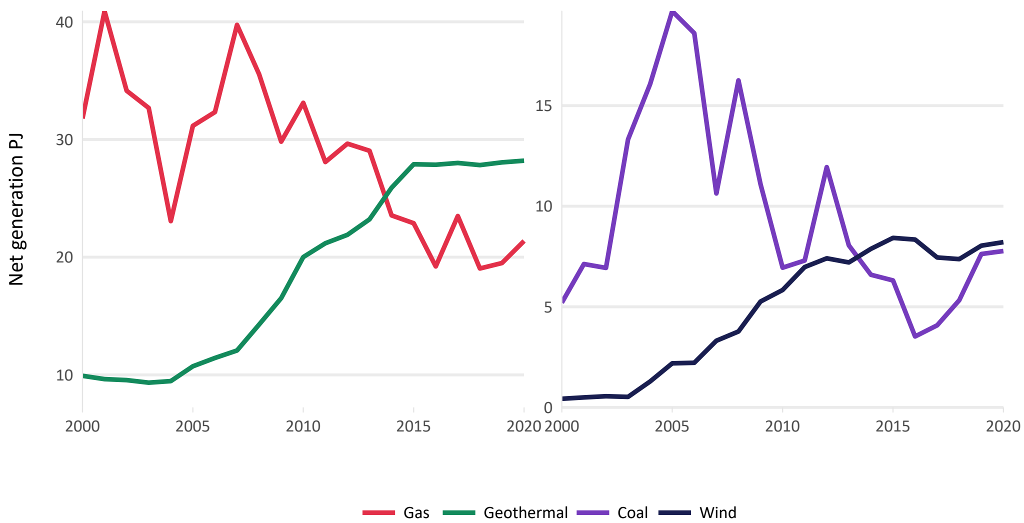
13 More information on Pohokura gas field production can be found in the Oil and Gas chapter.

in natural gas production, less gas was available for electricity generation. Therefore, there was an increase in electricity generated from coal. In 2020, electricity generated from coal made up 5.0 per cent of all electricity. This is the highest share of electricity generated from coal since 2013.

Major industrial users of natural gas were also affected by constrained natural gas supply. Methanex, New Zealand's largest producer of methanol, shut down its Waitara Valley plant and dialed back it's Motonui plant due to shortage in natural gas. This led to Methanex's production to fall to 76 per cent of total operating capacity. The strain in natural gas supply also caused an upward pressure on gas spot prices and electricity spot prices.

The electricity generation market appears to be moving towards more renewable generation. Although New Zealand relied more on thermal sources in 2020, Figure D.2 shows that electricity generation from geothermal sources has overtaken natural gas and generation from wind has overtaken generation from coal. With the commissioning and announcement of additional wind and geothermal plants, generation from renewable sources is likely to increase.

Figure D.2 Generation from renewable sources overtaking non-renewable sources



An additional 347 MW will be added to the renewable electricity market in the near future

2020 saw the commissioning of Junction Road natural gas peaking plant, Ngawha OEC4 geothermal plant, and Waipipi wind farm.[14] These three plants added an additional 226 MW to the market.

Several companies made announcements on new plants to support a greater renewable generation mix. A few construction projects such as Turitea wind farm have been delayed due to COVID-19 related supply chain disruptions. When these plants are complete, these plants will be adding a further 347 MW to the renewable electricity market.

This chart is based on information published by the Electricity Authority, supplemented with public announcements by companies. The Ministry has attempted to ensure the information presented is correct, however there may be instances where generation capacity and consent stage is misreported. More specific information on new plant developments can be found at the end of this chapter.

14 Waipipi wind farm was commissioned in November 2020. The additional capacity added is reflected in the data tables from March quarter 2021 onwards.

Table D.1 Electricity generation developments (MW)

Generation Type	Status	Start 2019	Start 2020
Gas	Consented		360
	Under Construction		100
Geothermal	Applied for consent		35
	Consented		282
	Under Construction		31.5
Hydro	Applied for consent	15	
	Consent Declined		46
	Consented		386.5
Wind	Applied for consent		100
	Consent Declined		18
	Consented	218	1434
	Consents Lapsed		125
	Under Construction	133	315

Box D.1 Battery Breakout Box

New Zealand's electricity generation is highly dependent on renewable generation, which is largely dominated by hydro generation. However in a 'dry year' – when we have less rainfall than average in a year – other sources are needed to make up the energy that water would have otherwise provided to generate electricity. At the moment those sources are fossil fuels. This is not consistent with the Government's goal for a 100 per cent renewable electricity system.

If we want to replace fossil fuels in dry years, we will need a renewable 'battery' that's big enough to store enough energy for an entire dry year sequence. This dry year problem could be exacerbated as New Zealand turns towards increasingly renewable energy sources like wind and solar, meaning we could face a more complex 'dry, calm and cloudy problem' in the future.

To help solve New Zealand's dry year electricity problem, in July the Government announced a $30 million investigation into pumped hydro against other potential energy storage solutions. With this, the three-phase New Zealand Battery Project was established.

Solutions being considered through the New Zealand Battery Project include a pumped hydro scheme at Lake Onslow in Central Otago, pumped hydro elsewhere, and other potential energy generation and storage solutions such as overbuilding renewable generation, biomass, biogas and green hydrogen.

The team is currently in the first phase of the project, in which they will evaluate the costs and risks of all these technologies, and advise government on how we can best manage dry year risk in a 100 per cent renewable electricity system.

What is pumped hydro?

Pumped hydro technology is used throughout the world and involves transferring water between two bodies of water at different heights. The water flows from one to the other through tunnels, passing through a power station.

When electricity demand from consumers is low or when surplus power is available, electricity is used to pump water from the lower level water reserve to fill the upper level reserve.

The water being stored in the upper reserve effectively becomes a battery, and can be released when it's needed during times of high demand or during dry years.

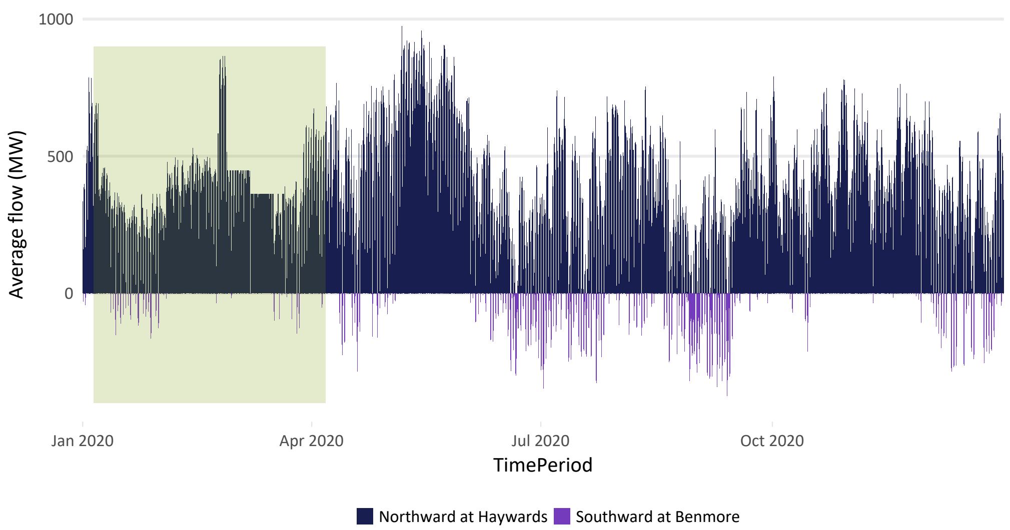
When the water is released from the upper reserve, it flows down the tunnels to drive turbines that generate hydro-electricity.

HVDC outage led to increased thermal generation in the North Island

Transpower undertook major refurbishment work on the HVDC inter-island link,[15] starting7th January 2020 for a period of 13 weeks to improve the resiliency of New Zealand's national grid. The HVDC outage meant that electricity generated in the South Island, where most of New Zealand's hydro generation is located, faced a transmission constraint when exporting electricity to the North Island. A transmission constraint means that there are limits to the amount of electricity that can be transferred through the HVDC. This contributed to South Island hydro generation being lower than usual. As the North Island is where most of the New Zealand's electricity demand is located, additional generation was needed in the North Island to make up the shortfall in electricity transmitted from the South Island.

In the week ended 12th January 2020, thermal generation contributed 16 per cent to the total generation mix.[16] On 18th January 2020, no HVDC transfer occurred due to a planned bipole outage. This was followed by a planned electrode outage from 19th to 31st January, which reduced HVDC capacity down to 406MW, in contrast to its normal transfer capability of 1200MW northwards and 850MW southwards. The additional generation in the North Island to make up for the shortfall in electricity transmitted was mostly thermal. Thermal generation in March quarter 2020 was 21 per cent higher than December quarter 2019.

Figure D.3 HVDC transfer



Demand

Commercial and industrial electricity demand fell, while residential demand increased

Electricity demand fell by 1.5 per cent (2.21 PJ) in 2020, driven by a decrease in demand from industrial and commercial sectors. While the agriculture, forestry and fishing sector, and the residential sector experienced increased demand, they did not offset the lower demand from commercial and industrial sectors.

Most of the country was dry and warm, causing soil moisture levels to fall in key agricultural regions in the South Island. Soil moisture levels are drivers of electricity consumption in agricultural regions.

15 Electricity transmission between the North and South Islands is done via a high voltage direct current (HVDC) link from Benmore power station in the South Island to Haywards substation in the North Island
16 Data available from https://www.transpower.co.nz/sites/default/files/bulk-upload/documents/Market%20Summary%20for%20week%20ended%2012%20Jan%202020_web%20version.pdf

The agricultural sector was also deemed to be an essential service and therefore was not subject to closure or production restrictions during COVID-19 Alert Levels 3 and 4. With lower than normal soil moisture levels combined with the sector being an essential service, this led to a 14 per cent (1.2 PJ) rise in demand from the agriculture, forestry and fishing sector. The closure of all non-essential industries and businesses, as well as schools, meant that there was an increase in the number of people working and studying at home. This contributed to higher daytime electricity usage, which led to a 2.5 per cent increase in residential demand.

Demand in the commercial and industrial sectors fell by 4.6 per cent and 4.8 per cent respectively. In addition to COVID-19 related restrictions on business activity, there were significant disruptions to global supply chains. Electricity demand in the pulp, paper, and printing sub-sector fell by 15 per cent (1.38 PJ), the largest demand reduction of all sub-sectors. The fall in electricity demand is reflected in the value of exports, with wood pulp and paper products falling by 13 and 7 per cent respectively.[17]

Table D.2 Changes in electricity demand

Sector	2019 (PJ)	2020 (PJ)	Change (PJ)
Agriculture, Forestry, and Fishing	8.8	10.0	1.2 ↑
Industrial	53.3	50.7	-2.6 ↓
Commercial	34.4	32.8	-1.6 ↓
Residential	45.4	46.6	1.2 ↑

Fourth potline at Tiwai point closed due to COVID-19 related pressures

New Zealand Aluminium Smelters (NZAS) is the single largest consumer of electricity in New Zealand. It uses about 35 per cent of total industrial demand and 13 per cent of total electricity demand in New Zealand. NZAS' majority owner Rio Tinto announced its decision to close the smelter following a strategic review due to rising electricity costs. The smelter has since reached a deal with Meridian Energy to continue operations until December 2024. Electricity futures prices rebounded in early 2021 following the announcement of that deal.

In March 2020, NZAS' majority owner Rio Tinto announced the closure of its fourth potline at Tiwai Point. The smelter was exempt from closure under COVID-19 Alert Level 4 due to the amount of resource involved in shutting down production. However, the decision to close the fourth potline was made due to falling international aluminium prices[18] as the global commodity market slumped, and needing more flexibility to manage the health and safety of staff. The fourth potline was previously shut down in 2012 due to low aluminium prices and rising wholesale electricity prices. It then re-opened in 2018 after international aluminium prices started to recover over 2017.

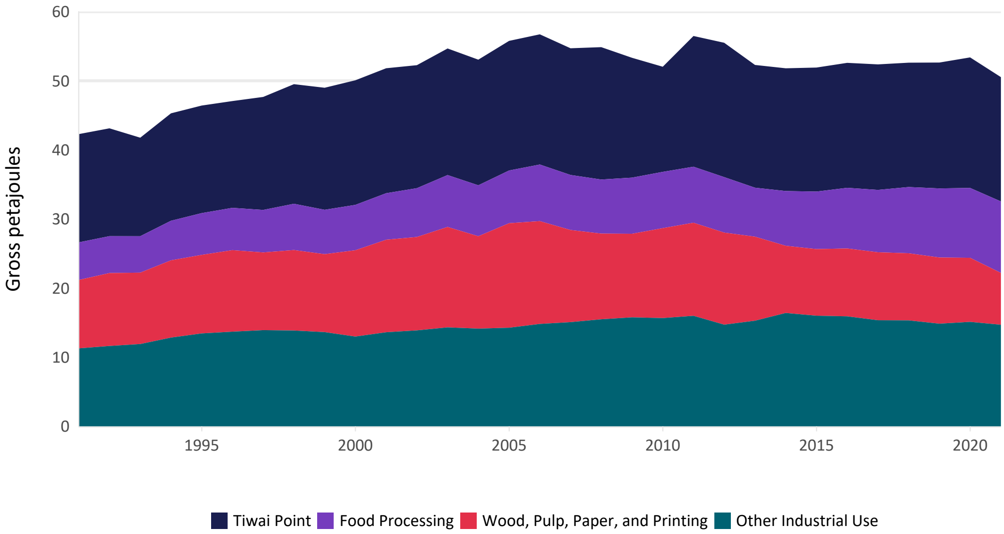
The potential closure of NZAS could signal future demand issues. With potential excess supply of electricity in the lower South Island, electricity will need to be transferred to the North Island where most of the demand is located. Transpower is undertaking the Clutha Upper Waitaki Lines Project (CUWLP)[19] as part of maintaining and developing New Zealand's national grid. With the completion of this project, the national grid will be better placed to support increased electrification. It also will reduce transmission constraints so that excess generation in the lower South Island (that may no longer be used by the Tiwai Point smelter if it closes in 2024) can be transported northwards. The project is expected to be completed by May 2022, and will bring the capacity to around 1,000 MW.

17 Data available from Stats NZ Goods and Services Trade

18 Aluminium was trading at USD$ 1,489 per tonne on the day of the announcement on the London Metal Exchange. International aluminium prices proceeded to drop as the global commodity market slumped with economies putting in place COVID-19 restrictions.

19 More information can be found at https://www.transpower.co.nz/clutha-upper-waitaki-lines-project

Figure D.4 Industrial electricity demand



Cost and Prices

Electricity wholesale spot prices remain high

The volume weighted average electricity spot price for 2020 was $114 per MWh. This was down slightly from the record high seen in 2019, but remains elevated when compared to the previous ten years, as shown in Figure D.5. Wholesale prices over the course of 2020 showed significant movements as illustrated in Figure D.6. Prices were subdued over the course of the initial COVID-19 Alert Levels 3 and 4 during March, April and early May. Prices then surged through the latter part of May, and June set the highest monthly average price for the year at $171 per MWh. Higher than usual prices persisted for the second half of the year. There were a number of contributing factors, including lower than usual rainfall in parts of the country resulted in a worsening hydro storage situation, as illustrated in Figure D.7, with average lake levels well below the historical mean. However, even after fresh rains boosted hydro storage to more normal levels by early October, average prices remained above $100 per MWh through November and December.

Another contributing factor to the elevated electricity wholesale prices was the ongoing tight supply of natural gas. For further information see Chapter F: Natural gas spot prices remain high.

Figure D.5 Annual average wholesale electricity prices

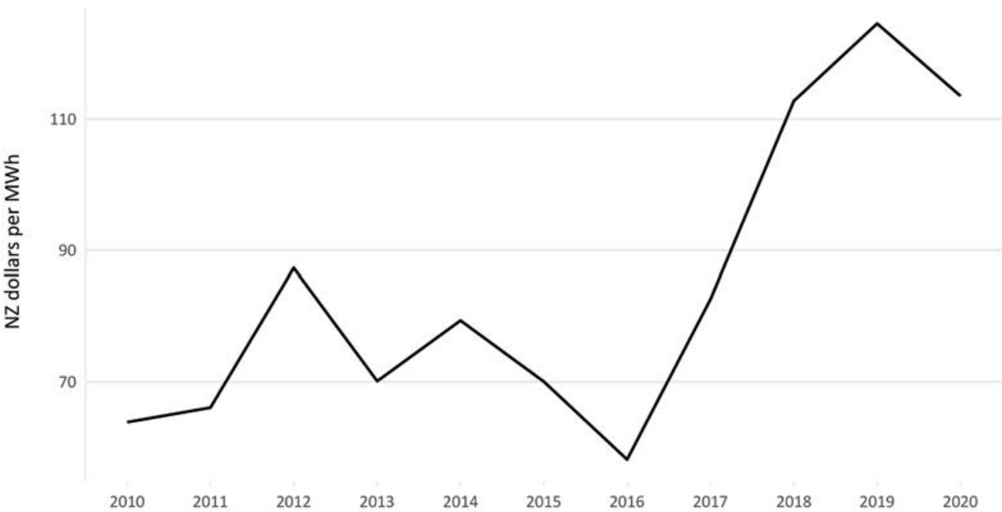


Figure D.6 Weekly average wholesale electricity price over 2020

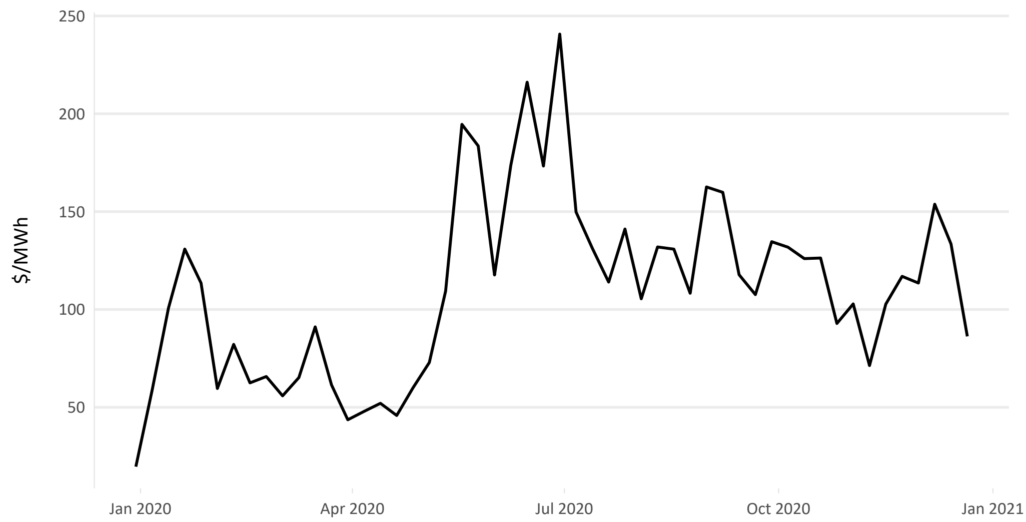
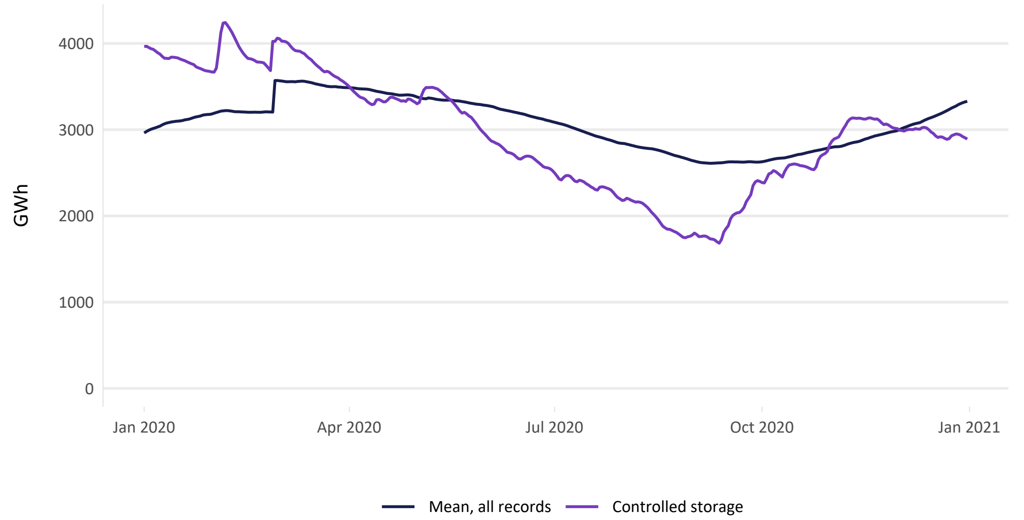


Figure D.7 Hydro storage in 2020



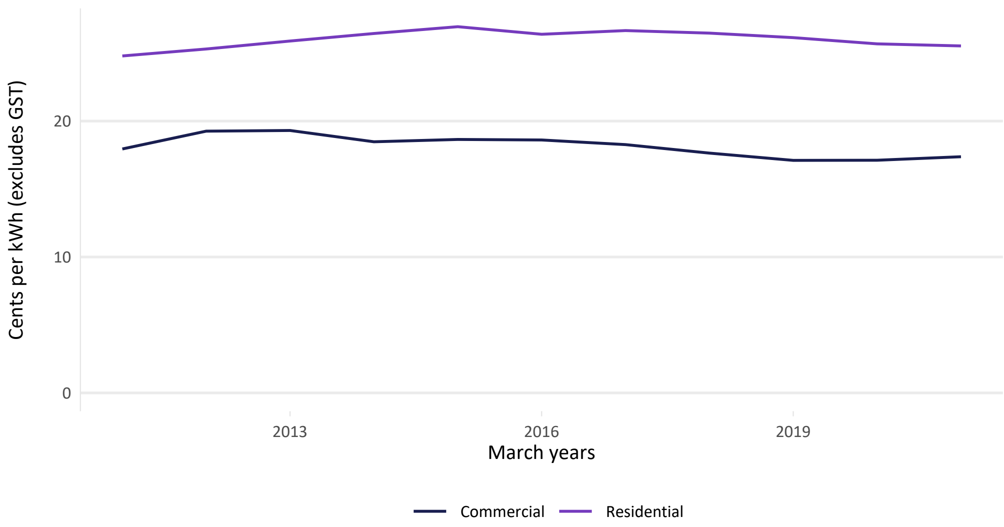
Retail Prices

Despite the high prices in the wholesale market, this did not flow through to impact residential and commercial consumers. As shown in D.8 the average electricity prices faced by these groups did not change significantly compared to previous years.[20] This is partly because electricity retailers have been sufficiently hedged through a range of market mechanisms so that they have not had to pass-on all of the wholesale price rises. The other significant factor is that while the energy component of retail prices increased around 12 per cent from mid-2018 to mid-2020, this was largely offset by falling transmission and distribution costs, which fell by around 9 per cent over the same period.[21]

20 Data from MBIE's Quarterly Retail Sales Survey

21 Data from MBIE's Quarterly Survey of Domestic Electricity Prices

Figure D.8 Trend of retail electricity prices



Box D.2

Electricity Price Review and energy hardship: Various initiatives are underway

After the release of the 2019 Electricity Price Review, work began on the recommendations set by the Minister for Energy and Resources. During 2020, the COVID-19 response and recovery resulted in some delays to this work, but at the time of publication all work is ongoing. Some key updates are provided here, but further information can be found on the MBIE website.

Defining Energy Hardship

Although work is ongoing to reduce experiences of energy hardship, there is currently no generally agreed upon definition of energy hardship for New Zealand. This was an EPR recommendation, and work continued in 2020, so that it can be measured and monitored. A discussion document for public feedback will be released in 2021.

Prohibiting Prompt Payment Discounts (PPDs) and Low-user Fixed Charges (LFCs)

The EPR recommended that both PPDs and LFCs be phased out to remove an element of market distortion that disproportionately impacts low-income consumers, and makes it confusing to compare prices. In 2020, the Minister of Energy and Resources requested information from electricity retailers about their use of PPDs, in order to inform decision making for the phase out.

Budget 2020 announcements

In August 2020 $17 million of funding was announced as part of a budget package for consumer advocacy and energy hardship. This funding was allocated to:

- Establishing an energy hardship expert panel and reference group
- Developing a network of community-level services to assist households in energy hardship
- Creating a fund for pilot programmes to improve energy efficiency for households in energy hardship
- Supporting the development of an accepted definition and indicators of energy hardship
- Forming an electricity consumer advocacy council

A further $28 million over four years was announced for the Māori and Public Housing Renewable Energy Fund.

Support for Energy Education in Communities (SEEC) and the Māori and Public Housing Renewable Energy Fund

Two funds were established in late 2020 with support from the 2020 Budget. The first round of SEEC funding (2020/2021) provided a total of $1.26 million to community organisations or business working to support energy wellbeing, efficiency and affordability. $4 million was available for renewable energy technologies in the first round, to be split between public and Māori housing.

Winter Energy Payment

A separate government intervention is the Winter Energy Payment, administered by the Ministry of Social Development. Understanding that COVID-19 would be economically challenging for households, as well as increasing the amount of time spent at home, the Winter Energy Payment was doubled in 2020. This meant that between 1 May and 1 October 2020, people receiving a main benefit were paid between $40.91 and $63.64 each week to help them stay warm during winter. The energy hardship expert panel and reference group recommended by the EPR will likely have some involvement in the overseeing of the Winter Energy Payment, and other energy hardship initiatives.

Up to date information about the EPR can be found at: https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-consultations-and-reviews/electricity-price/

Details of new plant developments

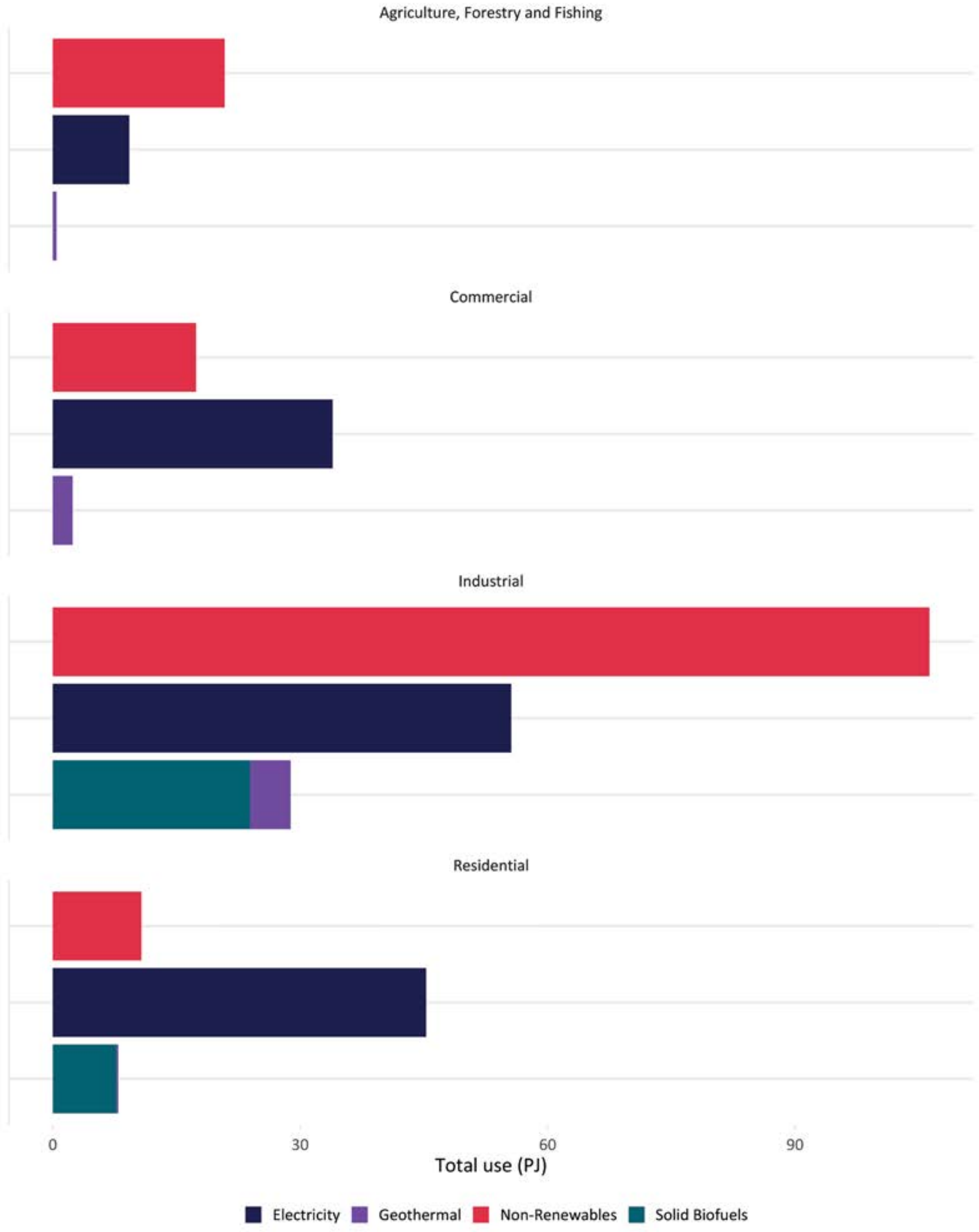
Generation type	Project	Developer/Owner	Additional information
Wind	Mt Cass wind farm	Mainpower	93 MW (Annual estimate 280 GWh on average).
	Waipipi wind farm	Genesis/Tilt	133 MW (Annual estimate 455 GWh on average).
	Turitea Stage 1 wind farm	Mercury	119 MW (Annual estimate 470 GWh on average). Construction for Stage 1 delayed due to COVID-19. Expected completion in October 2021.
	Turitea Stage 2 wind farm	Mercury	103 MW (Annual estimate 370 GWh on average). Expected completion in July 2023.
	Harapaki (Hawkes Bay) wind farm	Meridian	176 MW (Annual estimate 542 GWh). Expected commissioning in mid-2024.
Geothermal	Tauhara geothermal	Contact	152 MW (Annual estimate of 1,300 GWh). Due for completion mid-2023.
	Ngawha Geothermal Expansion Project	Top Energy	64 MW (Annual estimate of 250 GWh). OEC4 was commissioned December 2020. OEC5 expected completion in mid-2026.
Solar	Waikato solar farm	Genesis/unknown developer	300 MW (Annual estimate of 550 GWh)
	Wairau Valley solar farm	Kea Energy	1.85 MW Commissioned October 2020
	Kapuni solar farm	Todd - Sunergise	2.1 MW Commissioned June 2021
	Pukenui solar farm	Far North Solar Farm Ltd	16 MW (Annual estimate of 400 GWh).
	Lodestone Energy solar farm	Lodestone Energy	229MW over 5 solar farms in Northland, BOP and Coromandel. (Annual estimate of 400 GWh)
	Refinery NZ solar farm	Refinery NZ	26.7 MW. On hold.

E: Renewables

Direct use of renewables highest in industrial sector

Figure E.1 shows the five-year average of total energy demand in New Zealand by sector. It delineates the direct use of renewables (broken into major fuel types), non-renewables, or electricity use. It excludes the transport sector.

Figure E.1 Five-year average of energy end-use, by sector (excluding transport)



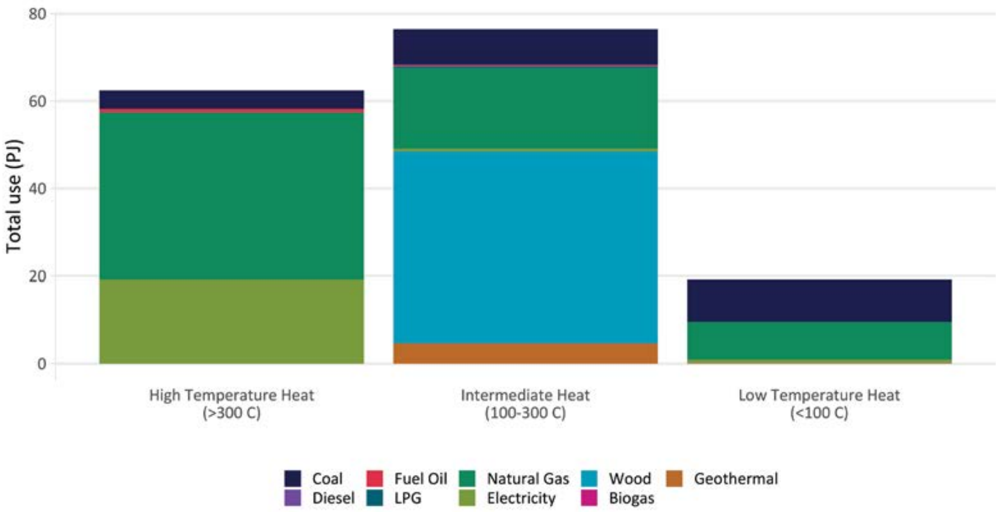
The graph shows that the industrial sector consumes the most energy of any sector, primarily for industrial process heat. Averaged over the last five years, 15 per cent of energy used in the industrial sector is associated with the direct use of renewable energy, as opposed to 56 percent from the direct use of fossil fuels.

The direct use of fossil fuels in industrial process heat needs to decrease in order to transition to a net zero carbon economy by 2050. This can be achieved by either shifting to the direct use of renewable fuels or switching to electricity, which is generated by a high (81.1 percent in 2020) and increasing share of renewables.

Process heat being targeted to reduce fossil fuel consumption

The Government is targeting industrial process heat as one of the best options for reducing New Zealand's fossil fuel consumption in the short to medium term. In 2019, industrial process heat accounted for 27 per cent[22] of New Zealand's total energy use, and 79 per cent of total energy use in the industrial sector. Figure E.2 shows the share of energy use within the different process heat temperature levels, for the industrial sector.[23]

Figure E.2 Industrial process heat energy use (2019)



Data sourced from the Energy Efficiency and Conservation Authority's (EECA) Energy End Use Database

The best opportunities for reducing fossil fuel consumption in process heat are in low and medium temperature process heat in the industrial sector given existing technologies. This share of process heat is generated mainly from boilers, and is used primarily in food processing and wood, pulp and paper production. High temperature process heat (eg. steel and chemical manufacturing) is more challenging to decarbonise. However, the Government is investigating complementary policy measures that support the Emissions Trading Scheme to encourage technological advancement and emissions reduction for high temperature heat processes.

The renewable energy fuel types available for use in process heat

Woody biomass: Woody biomass is useful because it can be used to deliver low, medium and high temperature process heat. However, there are constraints on biomass supply in some regions that lack forestry. Woody biomass is expensive to transport, so a local source of supply is more economic. Furthermore, the biomass market is still in its infancy. More information needs to be made available and market development needs to occur before potential users and suppliers will invest.

Electricity: For certain low and medium temperature process heat needs, where biomass is not viable, or there is a lack of biomass transport infrastructure, electric boilers and heat pumps can be

22 This data is updated using the Energy Efficiency and Conservation Authority's (EECA) Energy End Use Database. https://tools.eeca.govt.nz/energy-end-use-database/

23 Based on the EECA Energy End Use Database. Includes space and water heating.

used. Using electricity also follows the goal of increasing electrification of our energy use in New Zealand, which, alongside increased growth in renewable electricity supply, will decrease our reliance on fossil fuels.

Geothermal direct heat: Geothermal heat can be used as an energy source for process heat. Geothermal heat is currently used in timber drying, milk drying and toilet paper production, among other applications. Industrial operations would need to be large in scale to make it economic to drill a well solely for process heat use. However, geothermal heat direct use can complement electricity generation, so a lot of process heat applications currently sit alongside geothermal power schemes. The most economic geothermal projects will often be designed to offer a 'cascade' of applications according to what temperature is needed, recycling heat along the 'cascade'. This can suit different process heat needs as the cascade design can help to deliver high, medium and low levels of heat. Also, geothermal resources are only available in specific parts of the country, restricting its use to these regions (e.g. Taupō, Bay of Plenty).

The Government Investment in Decarbonising Industry fund

The Government Investment in Decarbonising Industry (GIDI) Fund, administered by the Energy Efficiency and Conservation Authority (EECA) is a partnership between Government and businesses to accelerate the decarbonisation of industrial process heat and contribute to the COVID-19 recovery by stimulating the domestic economy and supporting employment. It is a contestable process that will see $70M of capital grants made available to support projects through co-investment.

To date, the Government has announced nearly $28 million in co-funding for process heat decarbonisation projects under the GIDI Fund.

Z Energy (Z) biofuel plant made idle

Governments worldwide are introducing subsidies and other measures to encourage biofuel production. This has led to an increase in worldwide demand for tallow, a fatty by-product from meat processing. Tallow is used as a feedstock to produce some biofuels.

In early 2020, Z Energy mothballed its Te Kora Hou biofuel plant in Wiri. High prices for tallow paired with a major decrease in crude oil prices, made it uneconomic and less competitive for Z to continue to produce its tallow-based biofuel.

Z has plans to reopen the plant if and when it becomes economic to do so. The plant can supply a 5 per cent biofuel blend with mineral diesel that can be used without any engine modification.

In January 2021, the Government made an in-principle decision to implement a biofuels mandate across the transport sector. Public consultation was closed on the 26th July 2021.

Box E.1

Wood Fibre Futures report provides path forward for wood energy use

The Wood Fibre Futures report identifying potential wood processing technologies for use in New Zealand was released by the Ministry of Primary Industries in 2020.[24] The report scanned woody biomass use cases and opportunities from around the world, which have the potential to reduce emissions and would be feasible to implement in New Zealand given appropriate commercial and government support.

The report identified three new fuels with the best potential for use in New Zealand:

- Biocrude oil
- Liquid biofuels
- Carbon replacement for NZ Steel

In New Zealand there are large volumes of woody biomass that could be utilised to develop these three fuels and supply chains. As these fuels all require residuals, which are the parts of trees and wood remaining once sawn timber has been removed, a strong sawmill sector is key. The report found available woody biomass would be sufficient to support the new industries that could make use of these fuels.

24 The Wood Fibre Futures report can be found here https://www.mpi.govt.nz/dmsdocument/41824/direct

Hydrogen projects

Green hydrogen is part of the Government's current plans to decrease New Zealand's net emissions. Unlike brown hydrogen that is produced from fossil fuels and emits greenhouse gases, green hydrogen is produced by electrolysis which uses electricity to split water into hydrogen and oxygen. To be classed as green hydrogen, electricity used in generating hydrogen by electrolysis must also come from renewable energy sources, such as wind and solar.

Hydrogen fuel can help to decarbonise sectors that are difficult to electrify, such as the steel and ammonia industries. It also has applications in heavy transport vehicles like planes and trucks, similar to biofuels, where electric batteries are less suitable due to heavy transport's requirement for greater energy density to travel long distances.

Hydrogen projects that are currently under development or investigation in New Zealand include:

- Halcyon Power is a joint venture between Tuaropaki Trust and Japanese firm Obayashi Corporation to develop a 1.5 MW green hydrogen production facility in Mokai, Taupō.
- Ports of Auckland has an on-site electrolyser and is working with Auckland Transport and KiwiRail to deliver hydrogen fuel supplies.[25]
- Auckland Transport and Ports of Auckland unveiled the country's first hydrogen fuel cell bus in March 2021, which will run between Howick and Britomart.
- A $50 million joint venture between Ballance Agri-Nutrients Limited and Hiringa Energy Limited, compromised of $19.9 million co-funding from the Provincial Growth Fund, will see the construction of an industrial hydrogen production facility powered by four large wind turbines in Kapuni, South Taranaki. The green hydrogen will be used as both feedstock into Ballance Agri-Nutrients' ammonia-urea plant to reduce the plant's environmental footprint and as a

25 An electrolyser is used to create hydrogen fuel using water and electricity.

zero-emission transport fuel for local buses, trucks and cars. Hiringa Energy is also working with transport companies like TIL Logistics, and fuel retailer Waitomo. It intends to have a national network of 100 hydrogen refuelling sites by 2030.

- First Gas are undertaking a feasibility study, partially funded by the Provincial Growth Fund, to investigate whether hydrogen gas can be transported within our existing network of natural gas pipelines.
- The use of hydrogen fuel cell electric vehicle passenger buses is currently under investigation by leading tourism operator, Real Journeys.

Furthermore, a number of public and private sector organisations in New Zealand and South Korea have signed a Letter of Intent to progress a partnership to investigate the development of a large scale liquid hydrogen supply chain from New Zealand to South Korea. Also, New Zealand and Japan have also signed a Memorandum of Cooperation to signal their interest in working in partnership to develop hydrogen technology.

Box E.2

New Zealand becomes a member of the Clean Energy Ministerial group

In 2020, New Zealand became a member of the Clean Energy Ministerial (CEM) group. The CEM is a partnership of the world's leading economies working together to accelerate the deployment of clean energy technologies. It supports a broad range of clean energy policy and technology activities that together improve energy efficiency, expand clean energy supply, support energy systems transformation, and increase skills and recruitment in related industries.

Through the CEM New Zealand is now participating in:

- Electric Vehicle Initiative (EVI), which is a multi-government policy forum dedicated to accelerating the introduction and adoption of electric vehicles worldwide.
- Hydrogen Initiative, which has three initial focus areas for joint work:
  - Helping to ensure successful deployment of hydrogen for existing industrial applications.
  - Enabling deployment of hydrogen technologies in transport (e.g. freight, mass transit, light-rail, marine).
  - Exploring the role of hydrogen in meeting the energy needs of local communities.

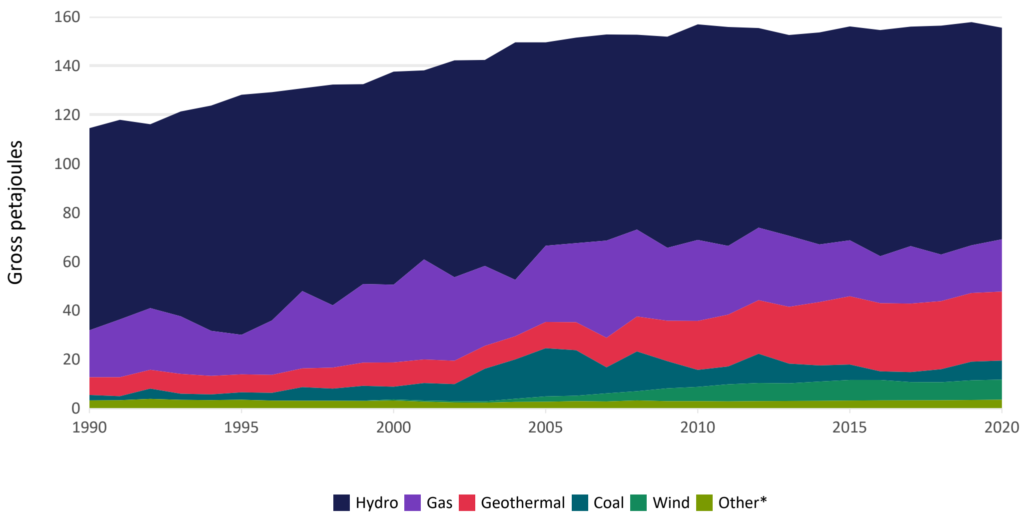
The CEM pairs political engagement among energy ministers and other high-level officials with technical initiatives and campaigns. Member countries propose and share leadership of those initiatives that help them achieve their own national clean energy objectives.

Low hydro lake inflows cause drop in renewable electricity generation

The share of renewable's in generation fell to 81.1 per cent. This is mainly due to a decline in hydro generation, which is largely dependent on hydro lake inflows. Hydro lake storage and lake inflows started off high at the start of the year, with hydro storage exceeding nominal full levels due to higher than normal rainfall in the South Island hydro catchments.

Subsequently, there was a warm and dry spell across most of the country. The warm and dry weather continued into the winter season. With below normal rainfall, hydro lake inflows fell below historical average for most of autumn and winter. This led to annual hydro generation dropping by 5.2 per cent.

Figure D.1 Electricity generation by type



*Other includes oil, waste heat, biogas, wood, and solar

2020 saw the commissioning of Waipipi wind farm, which started injecting to the grid in November. Generation from wind increased by 2.2 per cent compared to 2019. The capacity factor[26] for wind generation also increased to 37 per cent, slightly higher than the year before. This increase in capacity factor accounts for the increase in generation capacity. This suggests that wind conditions in 2020 was favourable for electricity generation. The September quarter of 2020 saw the highest ever generation from wind for a September quarter, exceeding 600 GWh.

Electricity generation from geothermal sources remained static, making up 18 per cent of total electricity generation in 2020.

There is more information about renewable electricity generation capacity developments in the electricity chapter.

26 Capacity factors tell us how much electricity was generated by a source over a period of time relative to the maximum amount that could have been generated based on its installed capacity.

Box E.3

Potential of supercritical geothermal resources are being considered

GNS Science was awarded a $10 million grant by the MBIE Endeavour Fund Research Programme in 2019 to undertake a 5 year project on supercritical geothermal resources in New Zealand.[27] The project scope is to delineate New Zealand's supercritical resources, and characterise their fundamentally unique chemical and fluid dynamic properties. Their mission is to advance the geoscientific understanding of New Zealand's supercritical resources and to de-risk exploration drilling.

Compared to conventional geothermal fluid (~3.5 km deep; <350°C), supercritical fluids from further underground (>5km deep, >400°C) have greater energetic potential. Supercritical fluids carry more heat at a lower density. Therefore, supercritical geothermal resources have the potential to supply heat to high temperature industrial processes and increase the efficiency and output of geothermal electricity production facilities. However, utilising New Zealand's deep supercritical resources requires an innovative approach to identify suitable locations and their geochemical conditions.

27 The project is called, Geothermal: The next generation. You can find out more about the project here: https://www.geothermalnextgeneration.com/

Solar adoption is heating up

Over 2019 and 2020, MBIE commissioned modelling on the potential for development of utility-scale solar photovoltaic (PV) generation in New Zealand out to 2060. This work included projections of capacity growth and annual generation output for solar PV farms connected to the transmission and distribution networks. The report summarising this work is accessible at: https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-publications-and-technical-papers/nz-generation-data-updates/

This report showed that the maximum potential development under New Zealand's current grid capacity and configuration is around 7 gigawatts. What's more, this potential capacity outlay could be achieved within 5 to 10 years if the right market conditions are met. The necessary market conditions, most importantly electricity price and build cost, were likely to materialise within the next 10 years the report found.

Other scenarios with differing assumptions found that the level of development may differ, but the potential for fairly rapid development to occur in the next decade was a common theme throughout.

It is important to note that the parameters and the assumptions for the modelling in this work were decided before the impacts of coronavirus (COVID-19) pandemic were realised so the actual trajectory may differ, especially in the short- to medium-term.

In early May 2021, the privately-owned renewable energy firm Lodestone announced plans to roll out 229 megawatts of utility-scale solar capacity throughout New Zealand over the next four years for a total project cost of $300 million. It expects to generate up to 400 gigawatt-hours per year and sell direct into the wholesale market.

Lodestone expects to start construction at the first of five sites, a 39 megawatt facility near Kaitaia later this year. The smallest of the farms – a 35 megawatt development near Edgecumbe – is about 17 times larger than New Zealand's biggest existing solar array. The other farms will be built at Dargaville, Whitianga, and the Waiotahe Valley outside Whakatane.

F: Oil and Gas

In 2020, New Zealand's domestic production of oil was 7.9 million barrels, of which 93 per cent was exported. Net natural gas production decreased from 178 PJ in 2019 to 175 PJ in 2020. Crude imports fell to 28 million barrels. In contrast, the imports of refined oil products increased from 22 million barrels in 2019 to 23 million barrels in 2020. Consumption of oil products and natural gas dropped 4.1 million barrels and 7.1 PJ, respectively.

Refinery intake decreased from 42 million barrels in 2019 to 30 million barrels in 2020 while refinery output fell 28 per cent or 12 million barrels. Due to low margins, environment and the effects of COVID-19, the refinery announced a strategic review of its operations in April 2020 and a decision on the future of operations will be made in 2021.

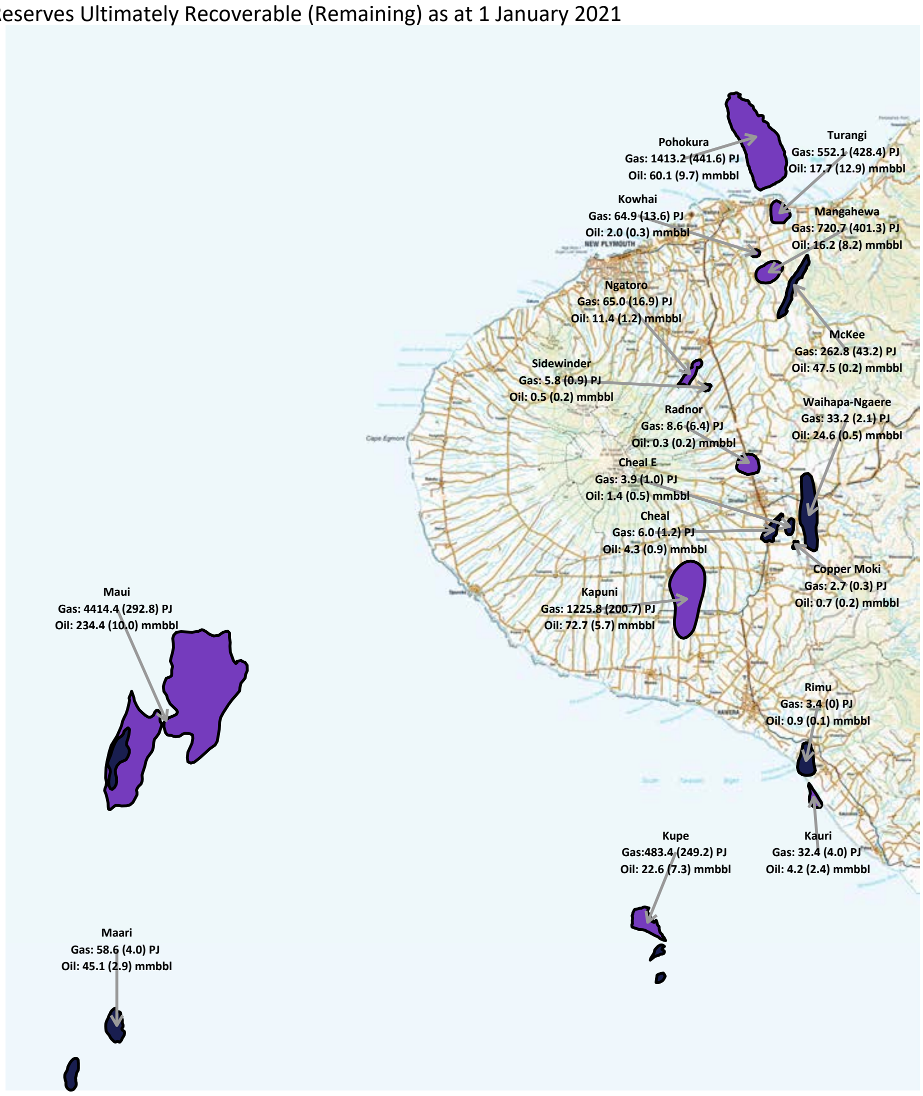
In 2020, a combination of the effects of COVID-19 and production issues at Pohokura resulted in lower oil and natural gas production compared to that in 2019. Excluding production in 2018 (which was much lower than usual due to an outage), natural gas production at Pohokura fell to a 10-year low. The combination of low electricity generation from hydro and tight natural gas supply contributed to higher wholesale electricity prices in 2020, which is similar to the situation in 2018. Please refer to the Electricity section for more details.

COVID-19 also dampened the use for oil and natural gas, with the exception of natural gas used in thermal electricity generation. Less air travel because of ongoing border restrictions saw a significant decrease in aviation fuels. The chemical manufacturing sector is the major contributor to the decrease in natural gas consumption. This is the consequence of a partial temporary shutdown at Methanex during COVID-19 Alert level 4, lower methanol prices, and reduced natural gas supply availability from Pohokura.

Reserves

Figure F.1: Map of Taranaki offshore and Onshore Oil and Gas Fields

P2 Reserves Ultimately Recoverable (Remaining) as at 1 January 2021

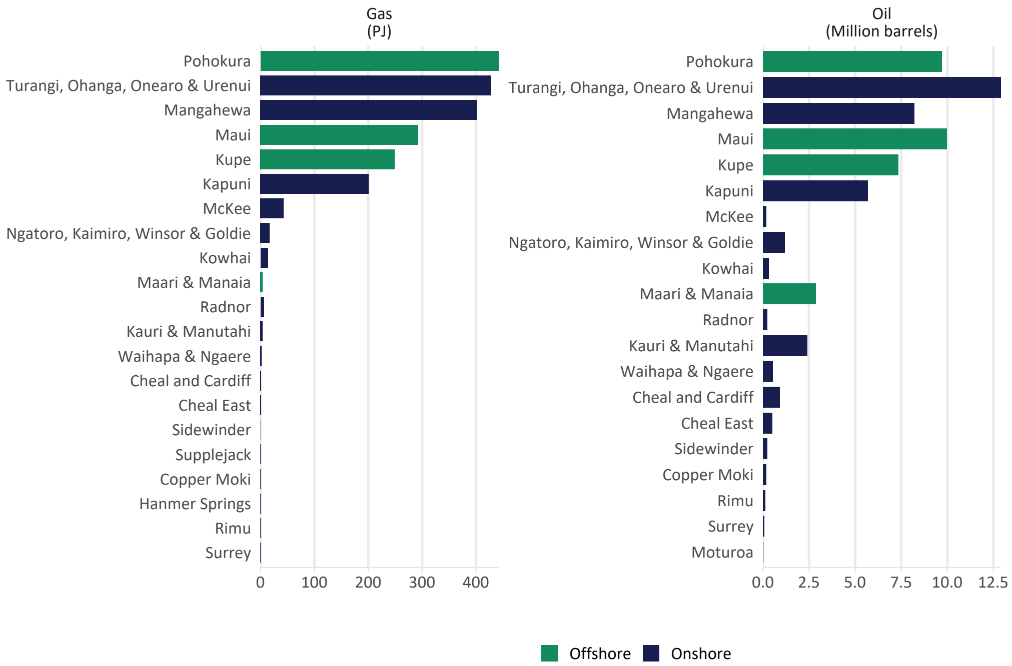


Gas Oil

The oil and natural gas reserves information was collected by MBIE via the annual summary reporting. This information presents how much oil and natural gas reserves remain in New Zealand. In contrast to oil, all natural gas production is used domestically.

Turangi reserves grow due to field development, while Pohokura's are revised down

Figure F.2: 2P Reserves

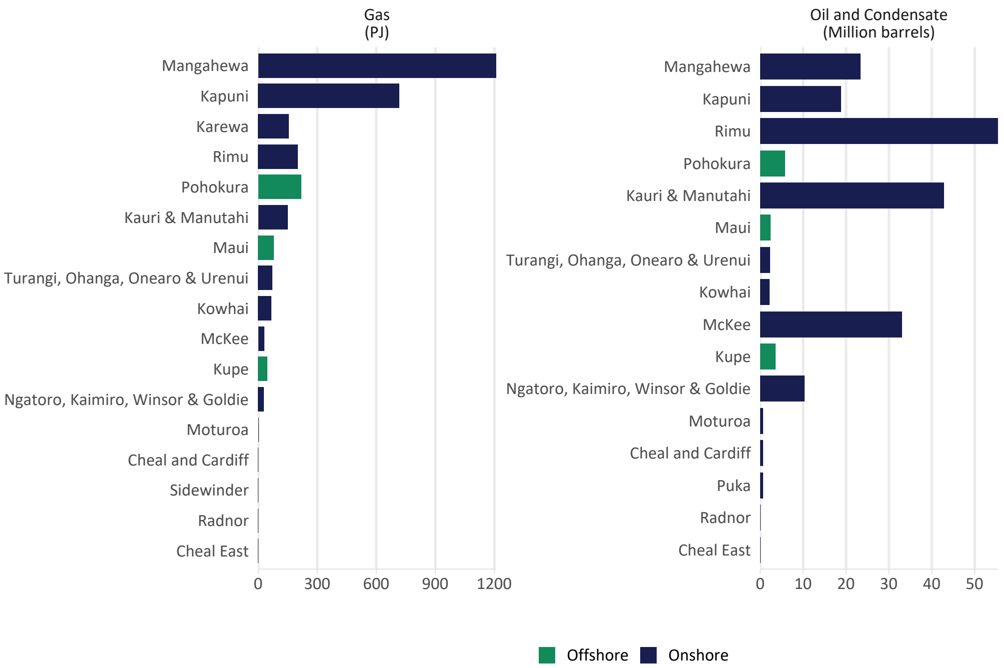


The figure above shows the remaining oil and condensate and natural gas reserves (2P) by field in New Zealand. As at 1 January 2021, total oil and condensate reserves were 62.5 million barrels and natural gas reserves were 2074 PJ. These reserves are estimated volumes of petroleum, from known accumulations that have been demonstrated to be producible under anticipated technological and market conditions.

Pohokura remains the largest natural gas field in New Zealand. Ongoing investment and development in existing fields increased natural gas reserves in Maui, Turangi and Mangahewa. A significant increase in natural gas reserves at Turangi was observed in 2020, with Turangi's reserves now exceeding Mangahewa's.

In terms of oil reserves, the largest three fields in 2020 are Turangi, Maui and Pohokura. Continuous field development increased the reserves in Turangi, and this field now has the largest condensate reserve. A high oil price environment after COVID-19 could support more developments in New Zealand oil fields. However, it is worth noting that the largest oil fields in New Zealand are also natural gas fields with associated condensate. The further development of these fields will depend on investors' views on longer term natural gas demand.

Figure F.3: 2C contingent resources

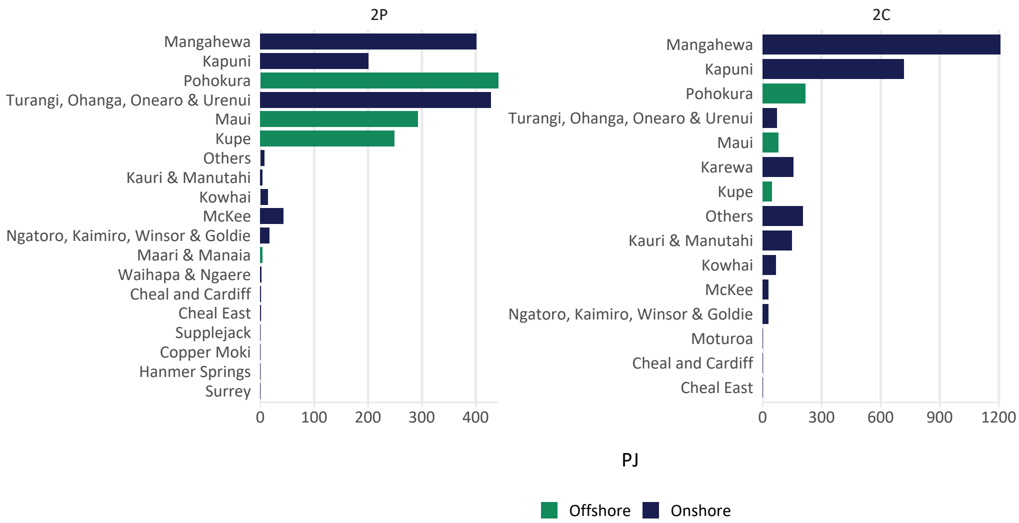


Mangahewa still has the largest volume of contingent natural gas resources.[28] Key changes in contingent natural gas resources were noted at Pohokura and Maui fields. The gas resources were revised up 112 PJ at Pohokura field, while the gas resources for Maui field were revised down 85.5 PJ. The revised resource numbers may be the result of production challenges at Pohokura and positive drilling results at Maui. In contrast, no significant changes were observed for oil contingent resources.

While it is important to understand that contingent resources will not necessarily translate into future supply, it is generally accepted that some contingent resources will be converted to reserves at some point.

28 Contingent resources represent oil or natural gas that has been discovered but may not be producible in practice due to physical or commercial constraints. They are therefore less certain than reserves.

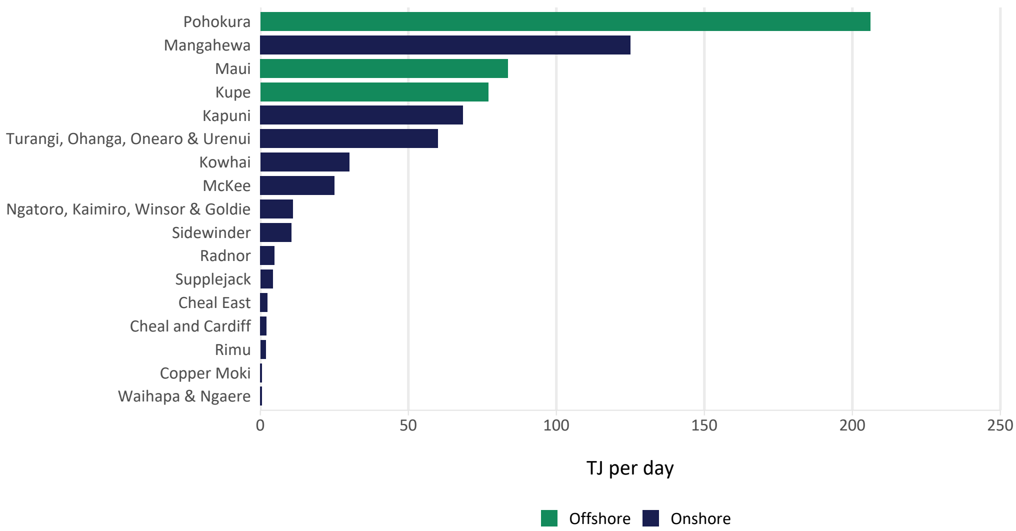
Figure F.4: Comparison of 2C and 2P gas reserves



Although Pohokura has the largest volume of remaining gas reserves, its contingent resources are relatively small. Turangi is in a similar situation. In contrast, Mangahewa has the greatest potential for the conversion of significant contingent resources to reserves.

Drop in Pohokura output led to lower natural gas production

Figure F.5: Gas deliverability



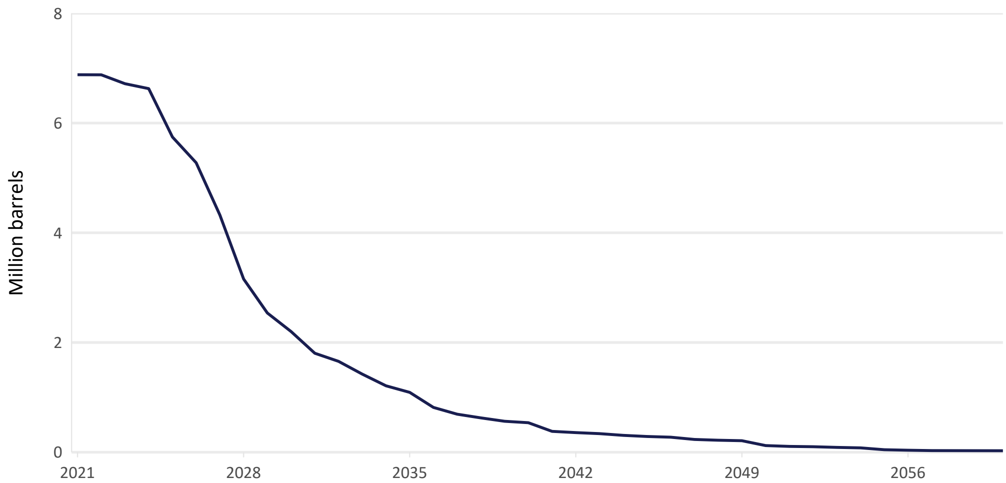
In 2020, Pohokura was still the highest-producing gas producer in operation in New Zealand. It produced up to 206 TJ per day in 2020, but its average production was 29 TJ per day lower than that in 2019. The decline in the production at Pohokura led to lower total gas production in 2020 than in 2019. In contrast, the average production at Maui and Turangi increased 10 TJ per day and 16 TJ per day respectively in 2020. In addition, a slight daily average production increase was observed at Mangahewa and Kupe.

■ Natural gas production expected to peak in 2024

The current forecast shows that operators expect a decrease in oil production in the near future, followed by a more gradual decline. In contrast, operators expect a sharp increase in gas production in the near future, reaching a peak in 2024. The increase in gas production is expected to be driven by drilling campaigns at Pohokura in 2022/23 and Maui and the ongoing developments at Turangi, Mangahewa and Maui.

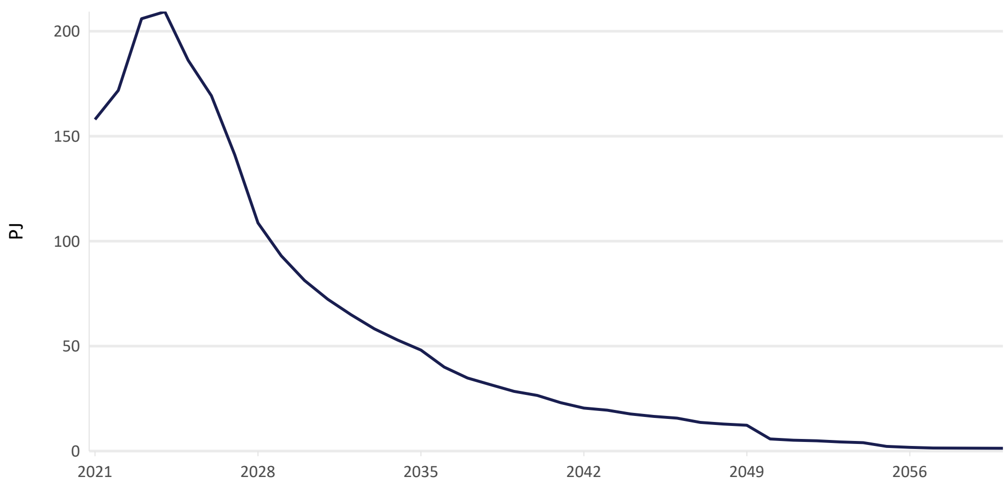
Future development plans by producers may change the shape of this production curve. We expect overall demand for gas to decline over time as New Zealand works to achieve its emissions reductions target.

Figure F.6: Oil production forecast



As reported to MBIE by field operators

Figure F.7: Gas production forecast



As reported to MBIE by field operators

Exploration and Development

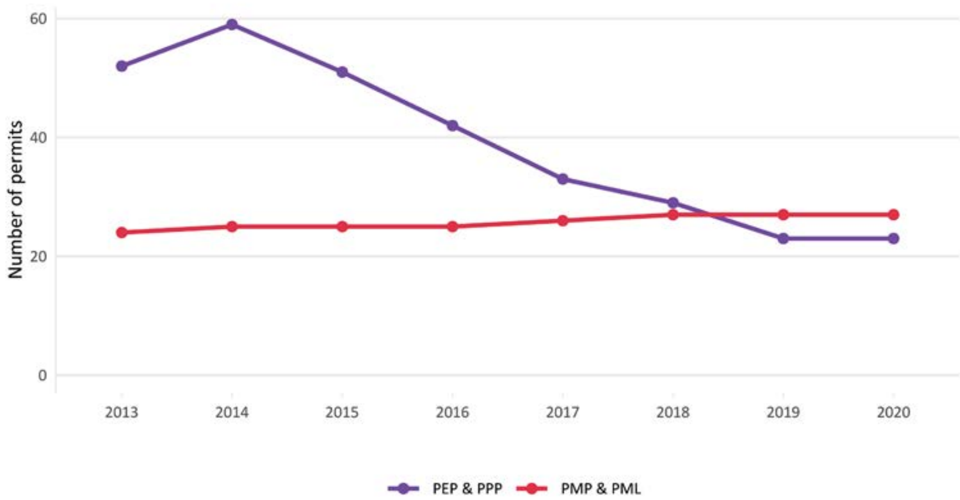
■ Exploration activity continued to decline in 2020

Drilling activities decreased with four new wells completed in 2020, compared to 12 in 2019. $260.9 million was spent on well drilling in 2020, up 11 per cent on 2019. No 2D or 3D seismic acquisition took place in 2020.

In 2020, Toutouwai-1 and Tawhaki-1 were drilled by OMV New Zealand. They are part of OMV's drilling campaign. Originally, three exploration wells were planned in the campaign, but only two of them were completed due to COVID-19 restrictions making it difficult to get skilled staff into New Zealand. Although the operation at Toutouwai-1 was halted, the preliminary results of the well were encouraging. If future appraisal activities confirm the initial drilling results, Toutouwai-1 could deliver a boost to New Zealand petroleum supplies. Tawhaki-1 was drilled in Great South Basin, but it failed to find any significant hydrocarbon. The failure of drilling result in the surrender of the exploration permit. As at 27 July 2021, no petroleum permit still exists outside of Taranaki.

Two appraisal wells were drilled in Turangi field in 2020, with one completed and the other one still being drilled as at 31 December 2020. Ongoing developments at Turangi provided a boost to production and reserves of Turangi.

Figure F.8: Number of petroleum exploration and mining permits



■ Oil companies surrendered permits back to the Crown

Oil and natural gas exploration and production can only occur within a permitted area. This means that the number of permits is an important indicator of future oil and natural gas discoveries and production. The number of exploration permits has been declining since 2014. This was driven by a low oil price environment and the 2018 prohibition of new offshore exploration permits. In contrast, the number of petroleum mining permits increased slightly. In 2019, the number of exploration permits was less than mining permits for the first time since 2002. The number of exploration and mining permits was 23 and 27 respectively in 2020, remaining the same as that in 2019. The acreage of permits decreased from 71,986 km^2 in December 2019 to 63,226 km^2 in December 2020.

Box F.1 Decommissioning the Tui Oil Field

The Tui oil field is located 50km off the Taranaki coast. Production from the field began in 2007 and was as high as 50,000 barrels of oil per day. Over its lifetime, Tui yielded approximately NZ $539 million in royalties.

Tamarind assumed control of Tui in 2017. Tamarind intended to extend the life of the Tui field by drilling three new development wells, which would have added approximately 5 years to the life of the field.

In 2019 the drilling of the first well failed to identify hydrocarbons, followed by withdrawal of financial support for the remaining two wells. This, and declining production, put Tui below the economically sustainable level. Production from the Tui field ceased in late November 2019.

Tamarind's obligation for decommissioning fell to the Crown when the company went to liquidation.

The decommissioning of Tui is being conducted in three phases:

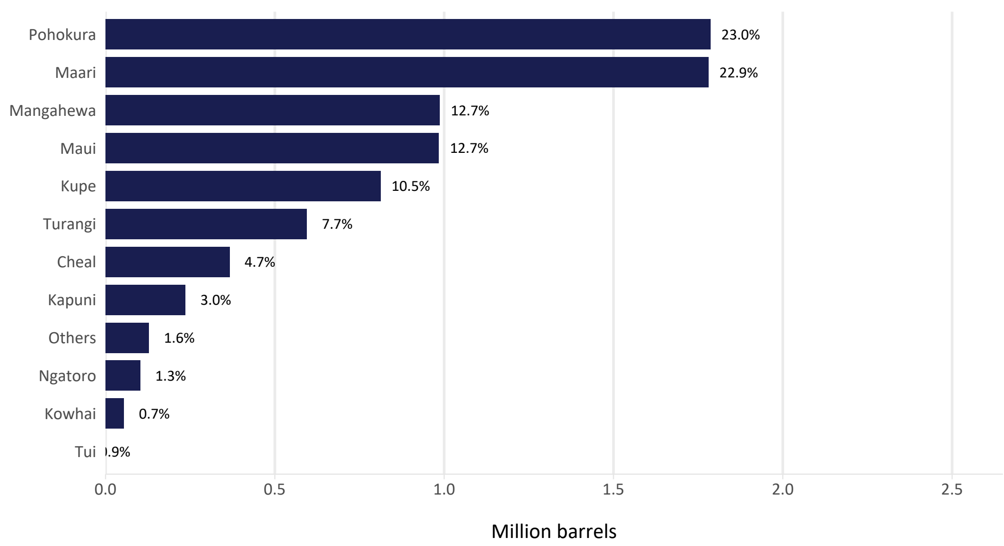
1. The demobilisation of the FPSO Umuroa, which was completed in May 2021,
2. Removal of the subsea infrastructure and
3. Plugging and abandonment of the wells.

MBIE expects decommissioning to take several years.

Oil

Drop in Pohokura output led to lower oil production

Figure F.9: Indigenous oil production in 2020



New Zealand indigenous oil production declined by 11 per cent (1.2 million barrels) in 2020. This was largely driven by the reductions in output at Pohokura, Maari and the decommissioning of Tui.

However, Mangahewa production increased from 0.7 million barrels in 2019 to 1.0 million barrels in 2020, which lifts its proportion in the total oil production in 2020. Mangahewa now exceeds Maui, taking third place in oil production. A significant rise in oil production was also noted at Turangi, which increased by 103 per cent compared to 2019.

Oil demand

■ Imports shifted from crude to refined product

Crude oil imports declined from 38 million barrels in 2019 to 28.0 million barrels in 2020. The Middle East remains the largest source of New Zealand's crude oil import, with the rest primarily coming from Russia and Malaysia.

Figure F.10: Crude imports by origin in 2020

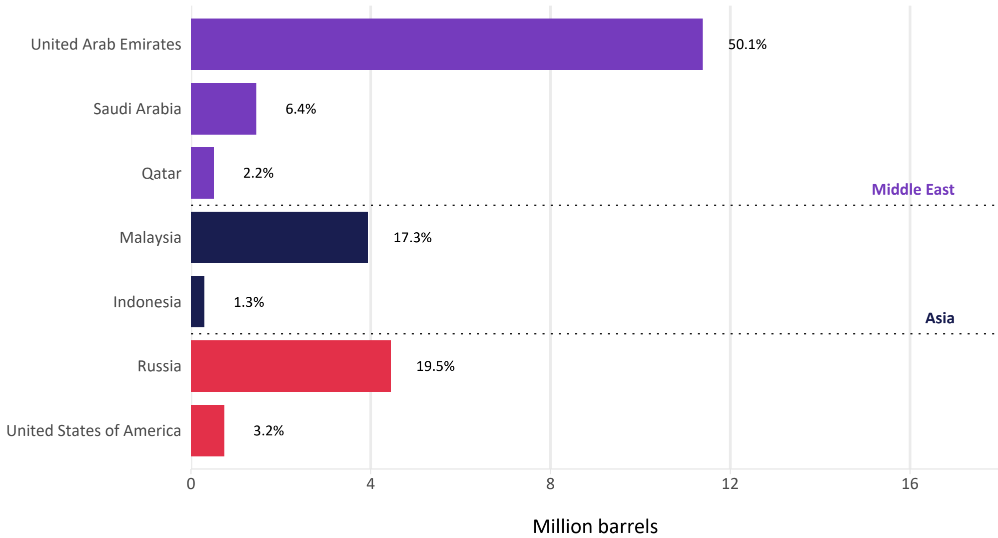
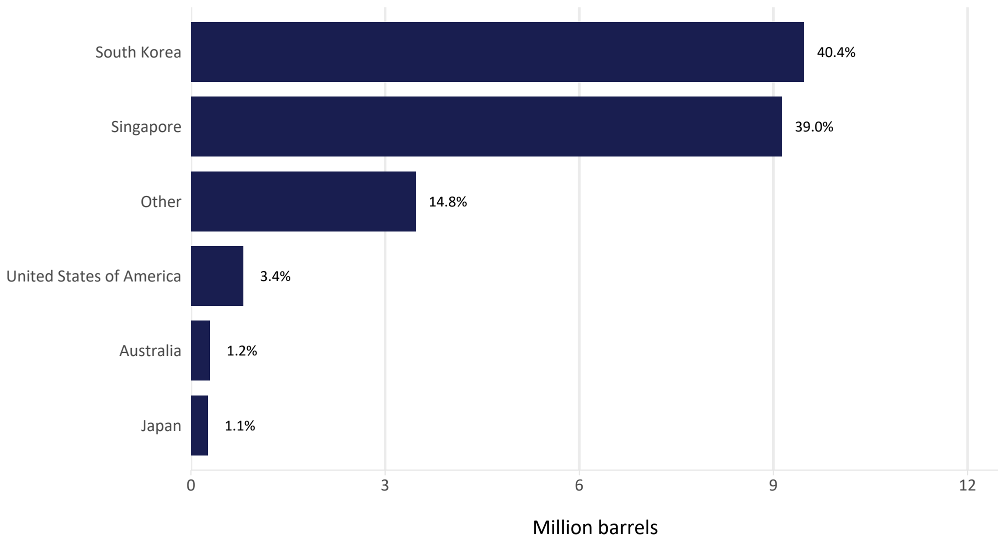


Figure F.11: Refined products by port of loading in 2020



Imports of petrol and diesel increased in 2020 by 8.3 per cent and 2.4 per cent respectively, reflecting reduced refinery output. In contrast with petrol and diesel, imports of aviation fuel decreased by 49 per cent (0.78 million barrels) on the previous year. This is likely to be due to less air travel in 2020. The majority of New Zealand's refined products are despatched from South Korea and Singapore, with 79 per cent of the refined product imports coming from these two ports.

Box F.2

Marsden Point Refinery Under Review

Almost all the domestic oil production is exported as it doesn't suit the current refining capabilities at New Zealand's only oil refinery in Marsden Point.

Modern, efficient and much larger refineries in China, Korea, Singapore and India are producing large volumes of low cost product, putting significant downward pressure on refining margins in Asia. Low refining margins do not allow Refining NZ to cover its cash costs under current processing agreements. Due to lower-than-expected returns, Refining NZ announced a strategic review in April 2020. In addition, in October 2020, the refinery finalised simplification plans which would allow it to continue to operate in the challenging environment of low refining margins and the effects of COVID-19, especially on Jet Fuel use. Although the strategic review is still ongoing, the simplification plans are already being implemented.

The strategic review options included:

› Continuing the current refinery model,

› Altering the refinery operating model,

› Separating refining and infrastructure assets,

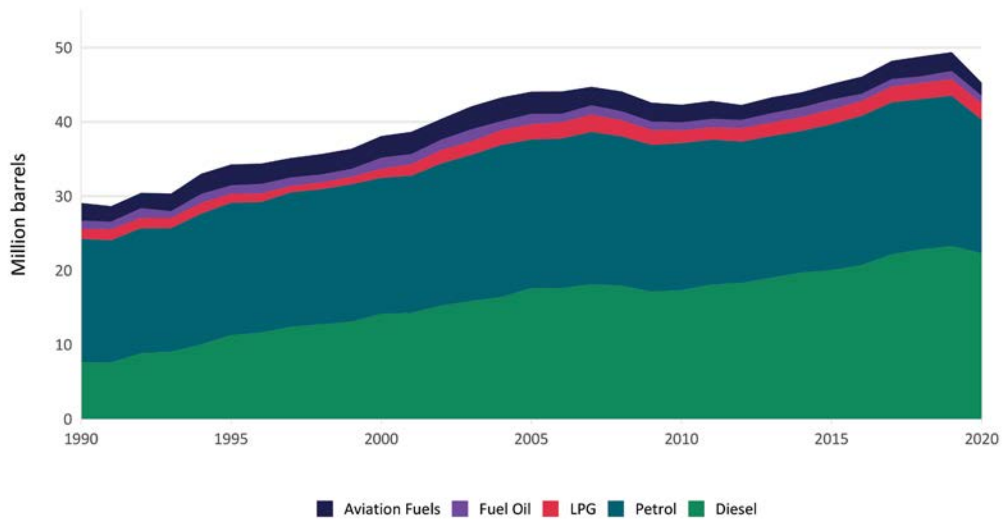
› Converting to an import terminal.

Indications from Refining NZ suggest that the refinery is likely to switch to an import terminal and Refining NZ will make a decision in August 2021.

In 2020, total intake at the refinery dropped significantly from 42 million barrels in 2019 to 30 million barrels. Total refinery output was down 28 per cent (11.7 million barrels) on the previous year due to effects of COVID-19 and the simplification of refinery operation. The refinery output of petrol, diesel and aviation fuel decreased by varying degrees. Among them, the most significant decline was in aviation fuel, which fell by 52 per cent (5.5 million barrels).

Aviation fuel and fuel oil consumption drop, while diesel consumption grows

Figure F.12: Domestic oil consumption by fuel

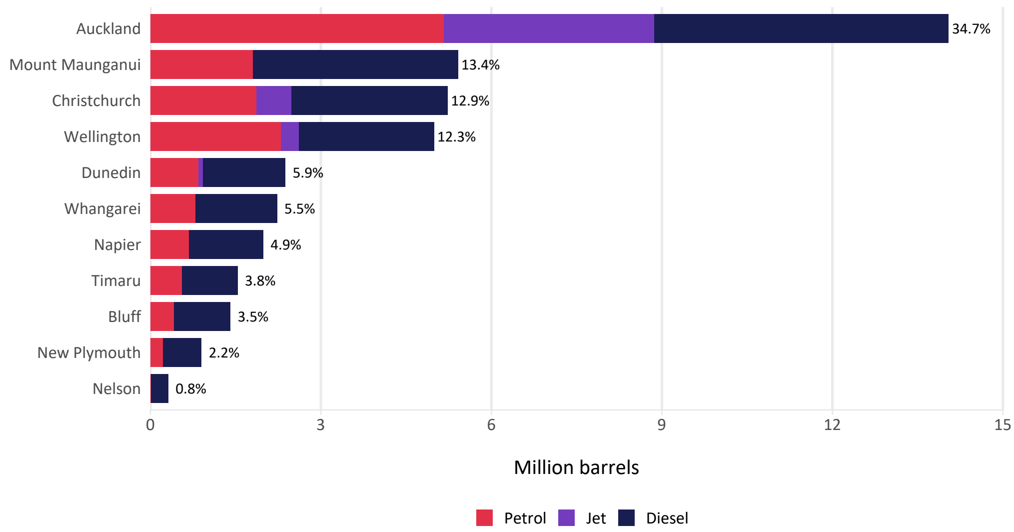


Domestic oil consumption declined 4.1 million barrels or 8.3 per cent in 2020, ending the consecutive year on year growth since 2013. All types of oil consumption decreased, with aviation fuel falling the most (down 0.78 million barrels or 31 per cent). The second largest decline was petrol, down 11 per cent or 2.3 million barrels.

The decline in oil consumption was driven by reduced activities during COVID-19 Alert Levels 3 and 4. The oil consumption reached a minimum for the year in the June quarter of 2020, followed by a rebound in the third and fourth quarter. Except for aviation fuels, the consumption of petrol and diesel have rebounded to pre-COVID-19 levels.

Oil consumption accounted for 48 per cent of the total energy consumption in New Zealand in 2020. Nearly all imported oil products are used for transport, with the majority used for land transport. To achieve New Zealand's zero carbon goal, particular efforts are needed to reduce the oil consumption in transport. Please refer to the COVID-19 chapter for more detailed analysis of the impact of COVID-19 on transport.

Figure F.13: Port offtakes by fuel in 2020



Port offtakes are a general indicator of regional fuel demand. However, care should be taken in interpreting this data, as oil products are transported between regions. The balance of regional demand was fairly similar to last year, with similar proportions of each fuel going to each region.

Box F.3 New Zealand's Oil Stocks

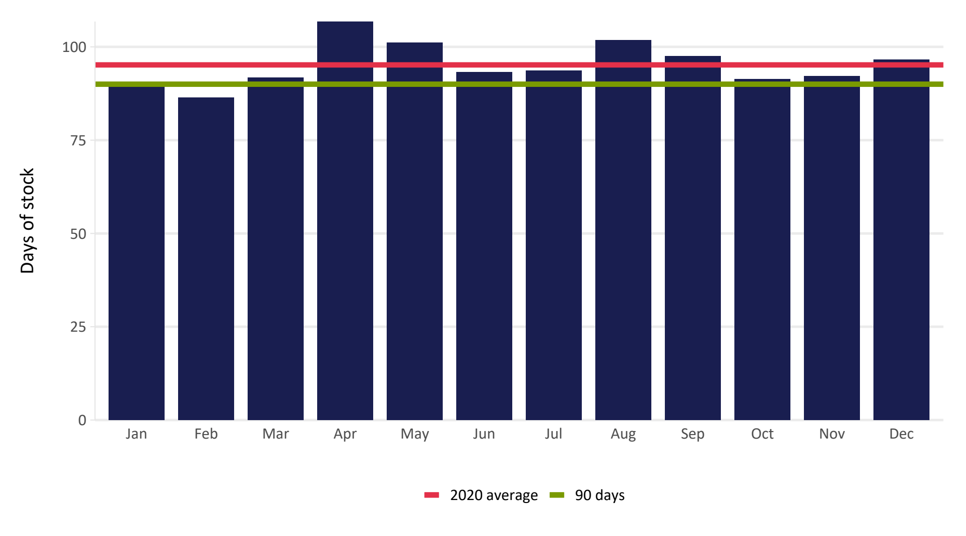
The International Energy Agency (IEA) was established in 1974 with the primary purpose of ensuring energy security around the world. It was formed in response to the oil crisis of 1973, where global oil prices increased significantly.

To enable a secure energy supply, member countries are required to maintain oil stocks that are equivalent to at least 90 days of net oil imports. This can be achieved through a combination of physical oil stocks present within a country's borders, and stock tickets purchased from other member countries.

Stock tickets are essentially contracts with other countries to hold a certain amount of oil in reserve for New Zealand, should we have a need to rapidly increase our stock levels. Stock ticket purchases are funded through fuel levies. As stock ticket prices have increased, the levies have also increased, to ensure there are sufficient funds available to maintain New Zealand's stock holding.

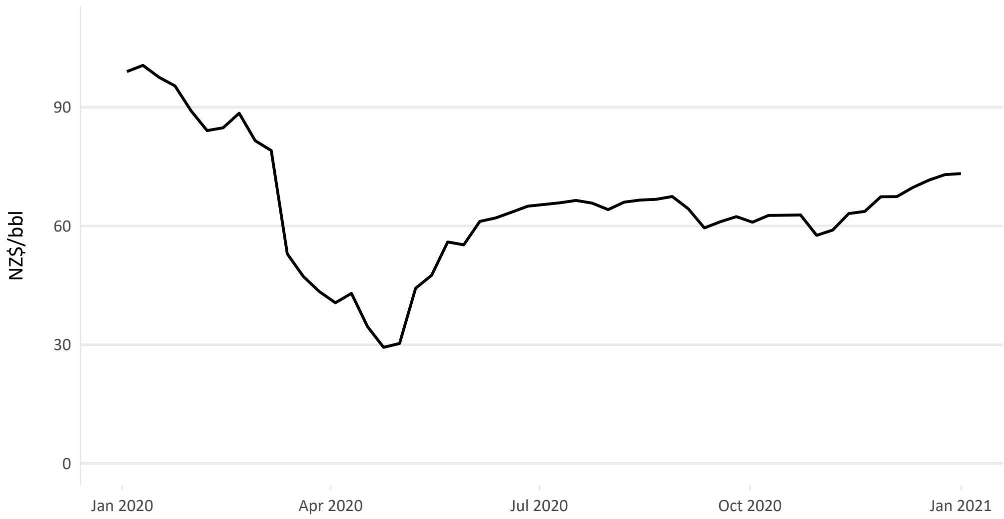
In 2020, New Zealand held on average 95 days of oil stocks. Monthly stock holdings can fluctuate around 90 days, depending on the timing of vessels arriving in New Zealand waters. Stock levels were at their highest for the year in April, as reduced use led to higher than usual stocks being held.

Box F.3 Figure 1: Days of stock



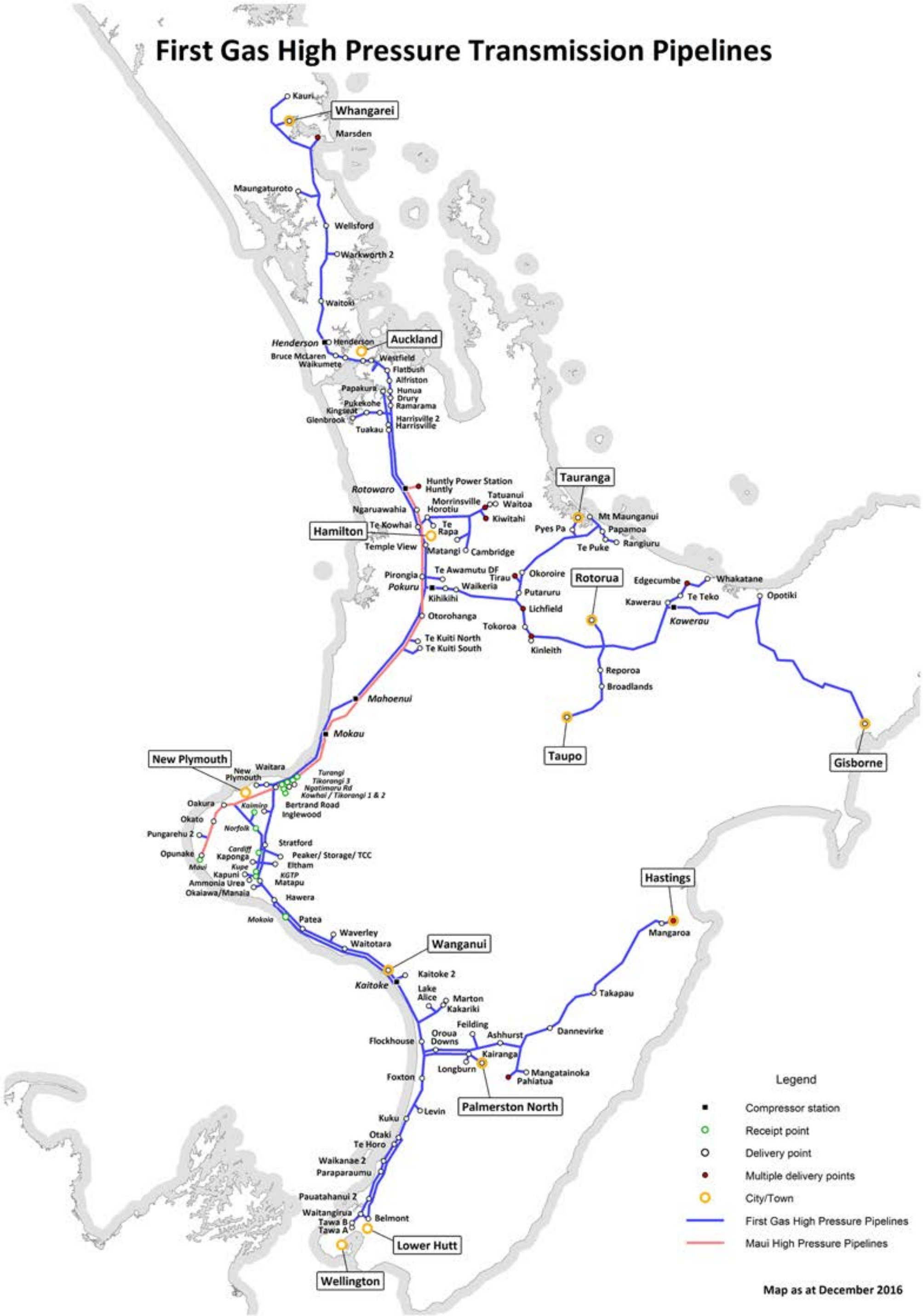
■ COVID-19 led to falling Global Oil Prices
International crude oil prices bottomed-out in early 2020 as the unfolding COVID-19 pandemic curtailed international demand, particularly travel. This flowed through to lower domestic prices for petrol and diesel (See COVID-19 chapter for further details). As shown in Figure F.14, crude prices had partially recovered by the middle of the year and remained steady from there.

Figure F.14: Dubai crude oil price over 2020



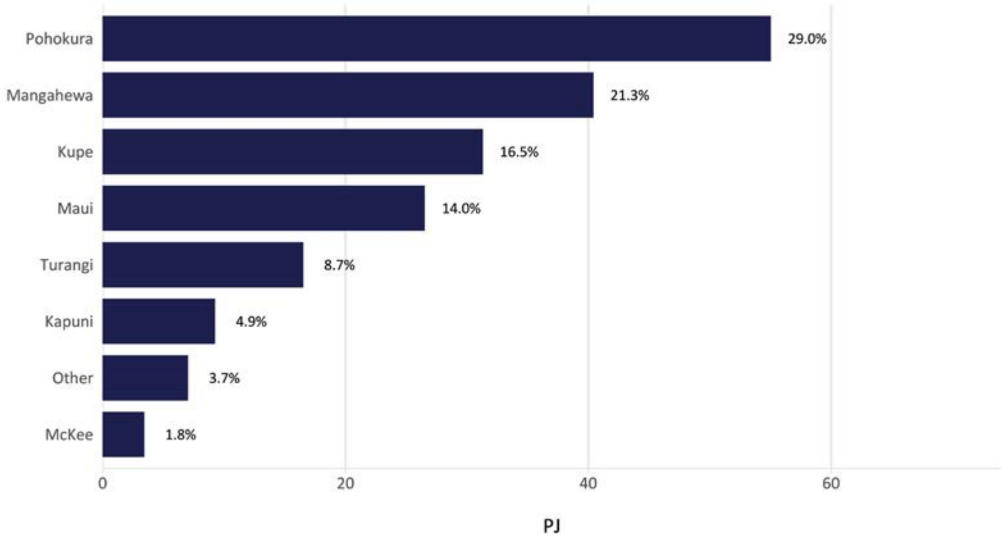
Gas

Figure F.15: Gas transmission map



Natural gas production fell due to declining Pohokura Production

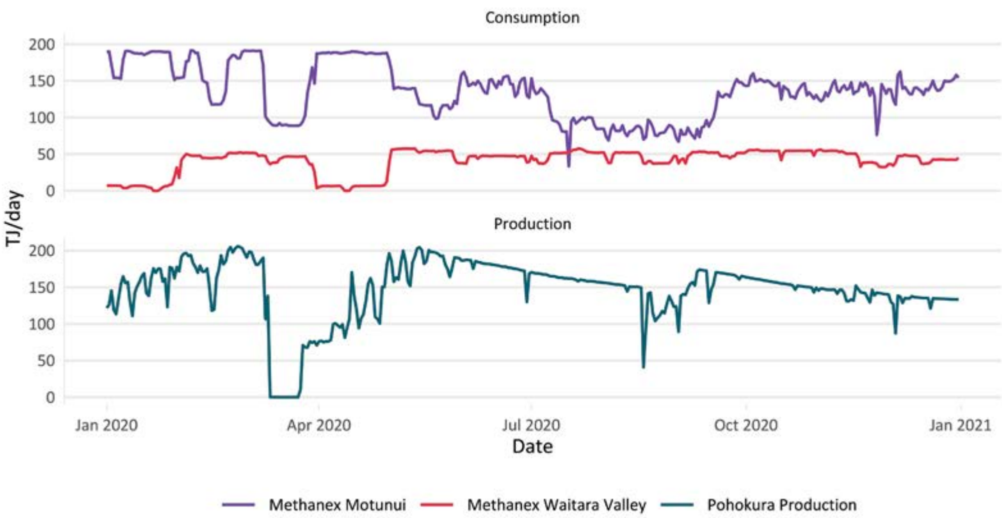
Figure F.16: Net gas production by field in 2020



Pohokura remained the largest field in term of net production in 2020. However, Pohokura's net production declined 14 PJ or 20 per cent on the previous year. In contrast, net production at Mangahewa and Turangi increased 3.2 PJ (8.7 per cent) and 6.7 PJ (71 per cent) respectively. Although ongoing field development increased net gas production at Mangahewa and Turangi, New Zealand's total net production fell 2.8 PJ in 2020.

■ **Pohokuras outage affected Methanex Waitara Valley**

Figure F.17: Pohokura daily production vs Methanex daily consumption

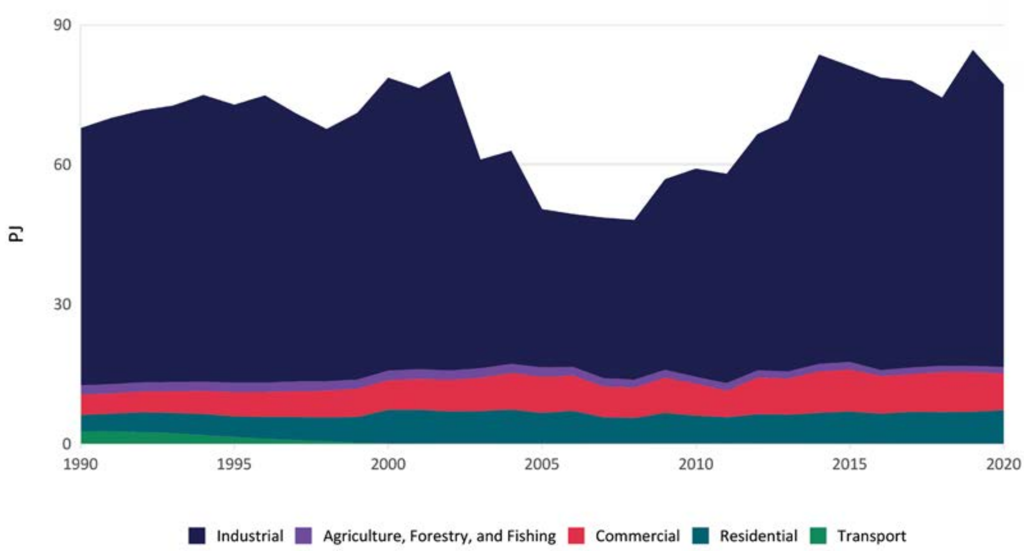


In 2019, Pohokura production recovered to 68 PJ after outages in 2018 due to a damaged pipeline.[29] However, production declined in 2020.

In late March 2020, Pohokura was temporarily closed for inspection work. This is reflected in the decline in gas consumption at Methanex Motunui plant, which as a major gas consumer was affected by the loss of production at Pohokura. Production climbed to 200 TJ per day in mid-May following the restart in April, but the production soon began to decline, resulting in a reduction in gas consumption at Motunui. A rebound of gas production was observed in September resulting in an increase in gas consumption at Motunui. The rebound, however, didn't stop the overall decline trend in Pohokura's production. Although Waitara Valley was shut during much of COVID-19 Alert Level 4, the gas consumption at Waitara Valley was stable for most of 2020. However, in January 2021 Methanex mothballed Waitara Valley due to reduced gas supply.

Industrial gas use fell due to tight supply and high demand for electricity

Figure F.18: Gas consumption by sector



Gas consumption dropped by 8.5 per cent (7.1 PJ) in 2020, with a decrease in all sectors except for the residential and agriculture, forestry and fishing sectors.

The Industrial sector was the major contributor to the decline in gas consumption, down 6.9 PJ (10 per cent), with chemical manufacturing sector declining by 3.0 PJ (8.7 per cent). This is primarily driven by the decline in Methanex's demand due to tight gas supply and low methanol prices. Also, consumption in the food processing industry dropped 2 PJ (9.2 per cent), ending three years of consecutive growth since 2017.

Gas used for electricity generation rose 11 per cent (4.1 PJ). The increase in gas used for electricity generation is a result of reduced hydro-electricity being available due to low rainfall. The long term trend for gas consumption in electricity generation has been declining, but flexible and reliable natural gas supplies will be critical to a low-carbon transition.

29 See Energy in New Zealand 2019 and 2020 for more information.

Natural gas spot prices remain high

The ongoing tight supply of natural gas has resulted in high natural gas spot prices. Although the natural gas spot market represents a small part of total gas trading activity, it is nonetheless a useful indicator of the underlying market dynamics due to supply and demand. Figure F.20 shows the trend of the volume weighted daily average price of natural gas on the spot market (courtesy of emsTradepoint). Spot prices averaged $10 per GJ during 2020. Prior to 2018 the price was usually around $5 per GJ. Prices rose in 2018 coinciding with an outage at Pohokura and continuing supply-side issues have exerted further upwards price pressure. In mid-March 2020, Pohokura underwent a two-week planned outage to carry out inspections and complete critical maintenance. Production from Pohokura showed a steady decline through the second half of 2020 and into 2021 as shown in Figure F.21.

The high price for natural gas has also been a contributing factor to the elevated wholesale electricity price over the last three years. Analysis of electricity prices can be found in the Electricity chapter.

Figure F.20: Trend of natural gas spot price

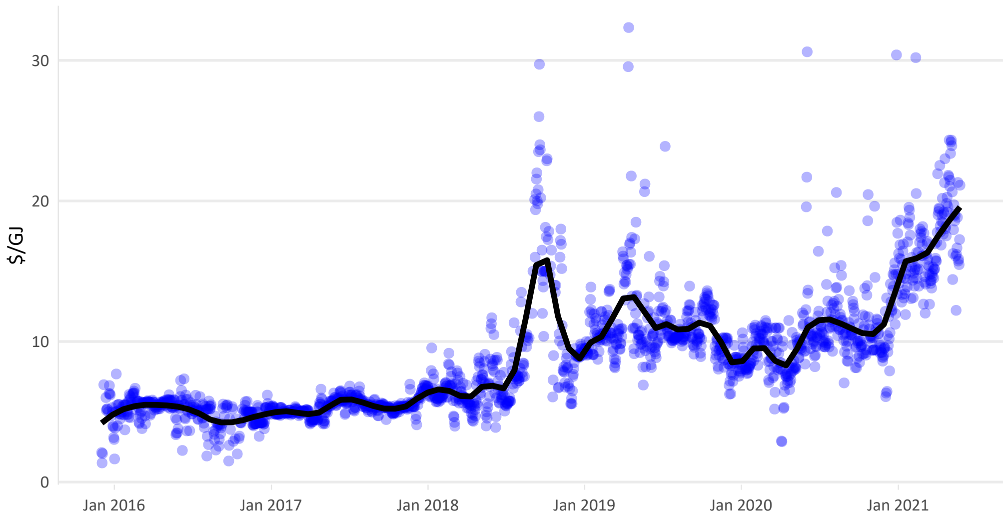
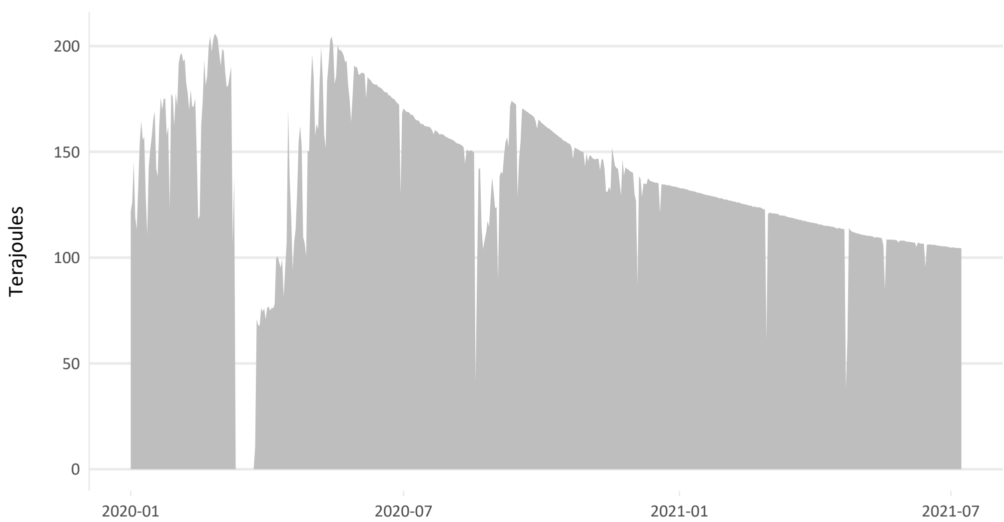


Figure F.21: Pohokura natural gas production



G: Coal

New Zealand's overall coal production dropped in 2020 due to the suspension of export coal production during COVID-19 Alert Level 4, and production constraints due to COVID-19 procedures. This was the lowest that production has been since 1991.

Bad hydrological conditions and a natural gas shortage caused an increase in coal use for electricity generation. This, and domestic coal production capacity constraints to meet the energy demand at short notice, caused an increase in coal imports, which remained at the highest level since 2007.

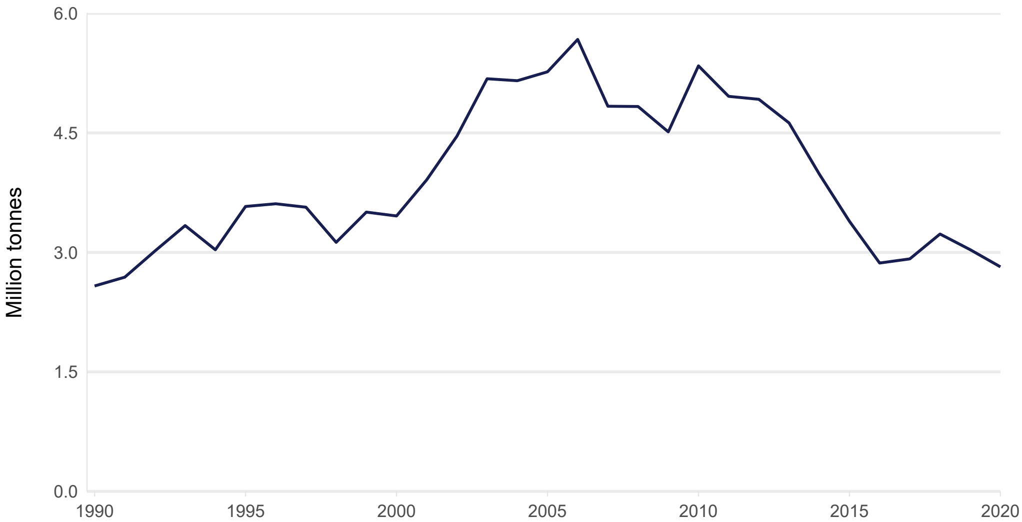
Coal exports decreased on the back of production and shipment suspension during COVID-19 Alert Level 4. Coal consumption also fell due to the impact of the pandemic.

There were 18 operating coal mines at the end of 2020 the same as in 2019.

Coal production

Coal production was 2.8 million tonnes in 2020, a decrease of 7.1 percent on the previous year.

Figure G.1 New Zealand coal production



Coal production in New Zealand for the year of 2020 was 2.8 million tonnes (73 PJ), a decrease of 7.1 percent from 2019. This was due to suspension of coal production for exports during the COVID-19Alert Level 4, and production constraints due to COVID-19 procedures in 2020.

Other aspects of New Zealand's coal production in 2020 include:

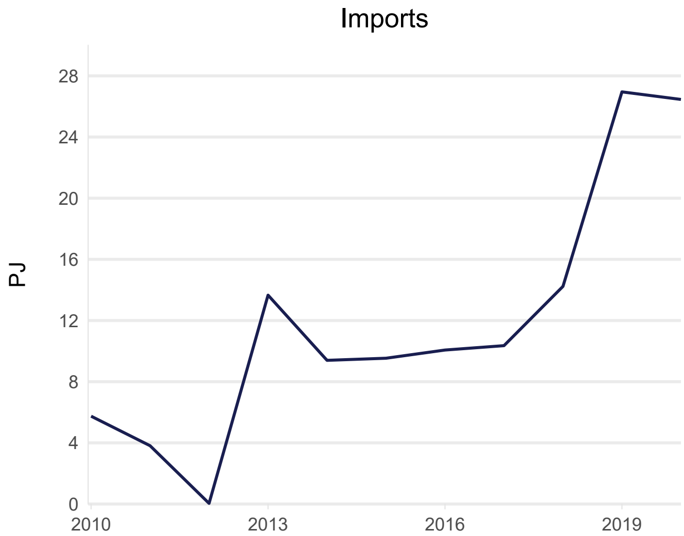
- Sub-bituminous coal production from both islands decreased in 2020 by 4.3 per cent on the previous year. Production from North Island mines was down by 5 per cent while the production from South Island mines decreased by 3.4 per cent.
- Bituminous coal production in 2020 decreased by 12.5 per cent on the previous year.
- Lignite production increased by 3 percent on 2019.

During the year 2020, we have received information that has clarified responses to the quarterly coal survey returns. This has resulted in an amendment to the volume of coal produced from underground methods since 2017. All coal produced since March quarter 2017 has come from open cut mines.

Trade

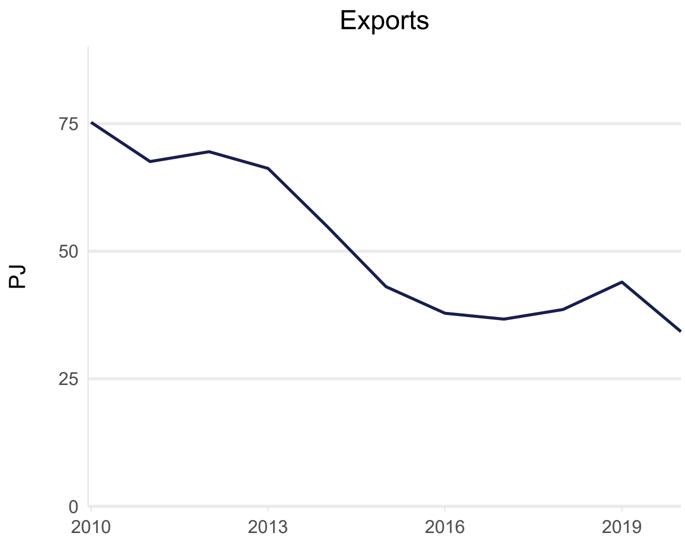
Coal imports on an energy basis decreased by 1.8 per cent in 2020 to 26.5 PJ, however on a tonnage basis coal imports increased 0.4% to 1.08 million tonnes, reflecting the increase in the imports of low calorific coal. This was due to the reduction in bituminous coal imports outweighing the increase in sub-bituminous coal imports, which was driven by the demand for electricity generation as well as constraints on domestic productions ability to supply the required amounts at short notice.
The majority of coal imports (95.5per cent in 2020) are sub-bituminous coal, used for electricity generation.

Figure G.2.1 New Zealand Coal Imports (Petajoules)



Coal exports decreased by 22 per cent to 32 PJ in 2020 due to production and shipment suspension during the COVID-19 Alert Level 4. The majority of coal exports (98 per cent in 2020) are bituminous coal (used in metallurgical applications (that is, the production of iron and steel).

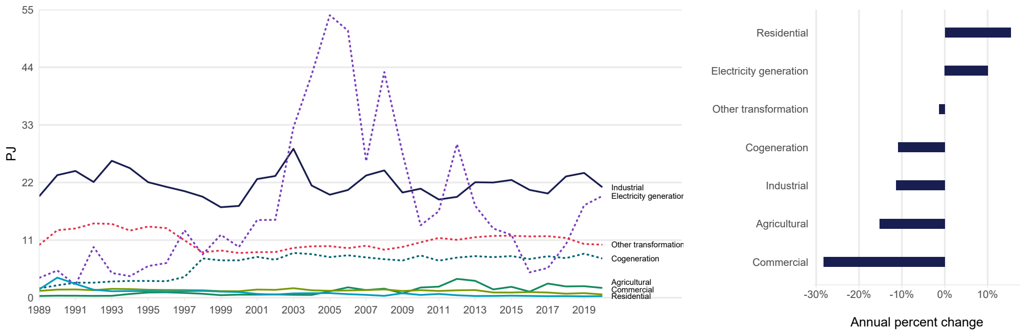
Figure G.2.2 New Zealand Coal Exports (Petajoules)



Coal use

Sub-bituminous coal use for electricity generation increased in 2020 on the back of a dry hydrological year and natural gas shortage. Other coal use was negatively impacted by the pandemic.

Figure G.3 Coal Consumption and annual percent change by Sector



Coal use can be divided between consumption (which is further divided into Industrial, Agricultural, Commercial, and Residential consumption) and transformation (which is divided into Electricity Generation and Other Transformation). The total primary energy supply of coal (calculated as production and imports less losses and exports) for 2020 was 61 PJ, a decrease of 5.4 per cent on the previous year. Coal accounted for approximately 7.0 per cent of New Zealand's total consumer energy supply.

Consumption

Coal consumption was negatively impacted by the pandemic. The reduction is mainly owing to a decline in agriculture, industrial and commercial use but partially offset by a rise in residential use. Coal use (predominately sub-bituminous coal) within New Zealand is currently dominated by industrial sector consumption, which includes dairy and meat processing, food product manufacturing, wood and pulp processing, metal and mineral processing, and chemical manufacture. Almost half of all coal consumed in New Zealand is used in industrial sector activities. Agricultural, Commercial, and Residential consumption make up approximately 12% of coal use in aggregate.

Coal consumption in the industrial sector in 2020 decreased on the 2019 level with total consumption at 24 PJ, a decrease of 12% on the previous year.

Transformation

Coal use for total electricity generation (electricity generation only and cogeneration)[30] increased 3.3 per cent due to the dry hydrological year and natural gas shortage. Sub-bituminous coal use for electricity generation only increased by 10 per cent while the use of, mainly sub-bituminous, but also lignite coal, for cogeneration (part of steel production or food production) decreased by 11 per cent.

The amount of coal use in the North Island is heavily influenced by Genesis' Huntly power plant. This power plant is the only coal-fired power plant in New Zealand, and is important for New Zealand's security of electricity supply requirements in dry years and amid a gas shortage to meet winter energy and peak demand requirements.

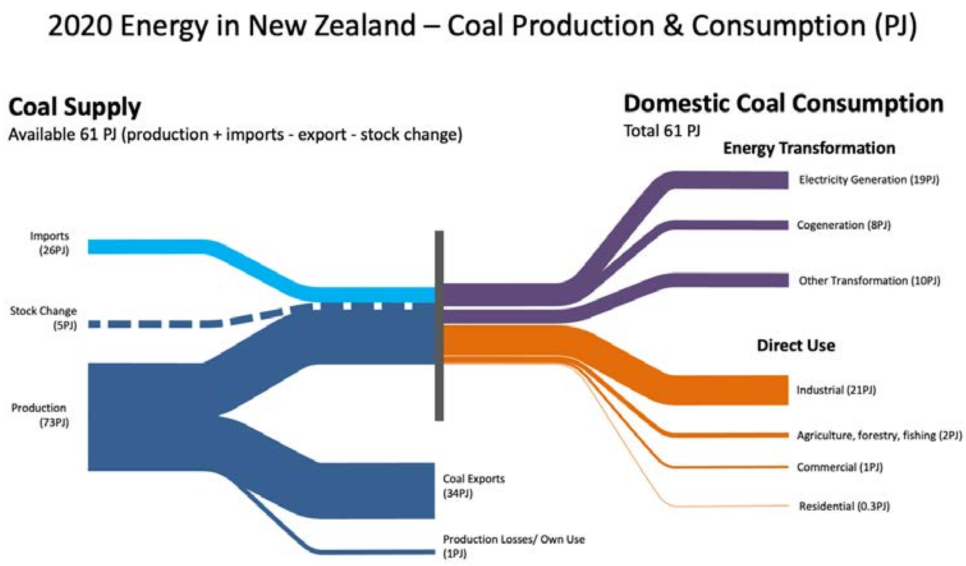
Coal use for other transformation processes (including iron and steel use) in 2020was down approximately 1.3 percent on 2019 figures.

30 Electricity generation only means that coal being used for generating electricity only. Cogeneration means that coal being used in a processing of generating electricity and producing useful heat at the same time for other purposes such as food processing or steel production.

Coal sector overview

Background information on New Zealand's coal industry can be found on the New Zealand Petroleum and Minerals website: https://www.nzpam.govt.nz/our-industry/nz-minerals/minerals-data/coal/.

Figure G.4 Coal overview in 2020



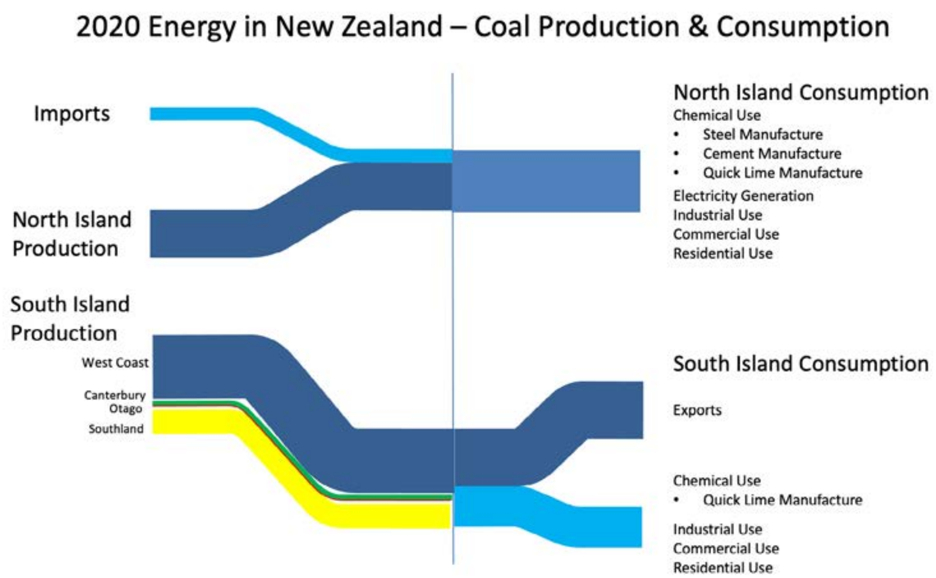


Table 1 Coal Supply, Transformation and Consumption (Petajoules)

Measure	Coal Use	31/12/2019	31/12/2020	Dec-on-Dec	% Change
Supply	Production	79.99	73.31	-6.68	-8.4%
	Imports	26.95	26.46	-0.50	-1.8%
	Exports	43.95	34.24	-9.71	-22.1%
	Stock Change	-1.25	4.78		
	Production Losses and Own Use	0.72	0.45	-0.27	-37.1%
Transformation	Electricity Generation	17.65	19.42	1.77	10.1%
	Cogeneration	8.41	7.49	-0.92	-10.9%
	Other Transformation	10.26	10.13	-0.14	-1.3%
Consumption (Observed)	Agriculture, Forestry and Fishing	2.21	1.87	-0.34	-15.3%
	Commercial	0.88	0.63	-0.25	-28.3%
	Industrial	23.83	21.10	-2.72	-11.4%
	Residential	0.27	0.31	0.04	15.4%

Coal sector background

New Zealand has extensive coal resources, mainly in the Waikato and Taranaki regions of the North Island, and the West Coast, Otago, and Southland regions of the South Island.

New Zealand's coal market can be divided into three distinct geological areas:

› North Island: In the North Island, coal production is centred on the Waikato region, where large coalfields like Maramarua and Rotowaro produce sub-bituminous coal. This coal is an excellent candidate for heating and energy generation, although it is generally not high enough quality to be used in metallurgical applications (that is, the production of iron and steel). The main consumers of this "thermal coal" in New Zealand are Genesis' Huntly coal power plant, and the Glenbrook steel mill south-east of Auckland. Unlike the vast majority of steel mills, the Glenbrook mill can use thermal-grade coal in the production of iron and steel due to the unique processes employed at the facility.

› West Coast: Coal extracted on the West Coast of the South Island comprises both bituminous and sub-bituminous coal, with the majority being bituminous coal. The bituminous coal produced is generally exported for metallurgical applications.

› Rest of the South Island: The rest of the South Island tends to produce either sub-bituminous coal, or the even lower-energy lignite. This low-energy coal is generally sold to dairy and meat processing plants throughout the South Island, and to households and companies for heating. It has been estimated that national in-ground resources of all coal are over 15 billion tonnes, although 80% of this is lignite in the South Island. Sub-bituminous and bituminous in-ground resources are around 4 billion tonnes, but economic reserves are much smaller.

The majority of coal used in New Zealand is consumed for energy use: the coal is burned to provide heat, whether that heat is used to dry milk powder, power a steam engine, run a boiler, or heat a house.

There are also two major non-energy uses for coal in New Zealand:

› At Huntly power plant, the energy in the combusted coal is used to drive turbines which generate electricity. As the energy contained within the coal is not used directly at Huntly, but merely transformed into a different form, we do not consider this to be "energy use".

› At Glenbrook steel mill, coal is used as a reducing agent, converting magnetite in ironsand to metallic iron. While it may provide energy, its primary purpose is as a reagent in a chemical reaction. As such, this is also not considered to be "energy use".

H: Special Feature: Future Energy Trends

Background

In 2019, MBIE published the Electricity Demand and Generation Scenarios (EDGS 2019) which describes five different narratives. The purpose of the EDGS is to enable the Commerce Commission to assess Transpower's planning proposal for future grid investment. One of the scenarios in the EDGS 2019 describes how electricity demand and supply could evolve under current policies and technology trends. This particular scenario is called the "Reference scenario". It is important to note that the Reference scenario is not MBIE's view of a likely energy future as it does not include the significant amount of new policy that is being developed by the government to support decarbonisation.

Since the release of EDGS 2019, the world has experienced the outbreak of COVID-19 and we are still suffering from the aftermath. The pandemic will leave a permanent impact on the global economy with implications for global energy demand and supply.

MBIE updated the Reference scenario to incorporate the impact of COVID-19 in the 2021 projection. MBIE provided this updated energy projection to the Climate Change Commission (CCC) so that the CCC could use it as part of their technical analysis when they finalised their baseline scenario. The purpose of the baseline scenario is to understand how the energy sector will change without new policy intervention to support emissions reduction, and understand what New Zealand might need to do to meet our emissions budgets.

In this projection, we incorporate the latest energy and economic data and use an updated 2020 generation supply stack.[31] The EDGS 2019's Reference scenario assumes that carbon prices will increase to NZD$66 (in 2017 dollars) per tonne by 2050. In the updated projection, we assume a constant $35 per tonne in real terms in 2019 dollars and have modelled a sensitivity analysis of a higher carbon price. In this sensitivity analysis, emissions values for carbon reaches $250 per tonne by 2050.

2. Near-term projections

As a result of the global economic disruption caused by COVID-19, we see a significant fall of 7.4 per cent and 6.7 per cent in New Zealand energy demand and energy CO2 emissions respectively in 2020 in this projection.[32]

The Treasury's Half-Year Economic Fiscal Update 2020 (HYEFU 2020) forecasts 4.5 per cent GDP growth in the 2021 calendar year and a fall of 4.6 per cent in 2020. Although the New Zealand economy has weathered the COVID-19 shock much better than other developed economies, Figure H.1 shows that the New Zealand economy is not expected to return to its pre-COVID-19 forecast level of GDP[33] in the near term.

As GDP growth is a key determinant of energy demand, growth in energy demand in 2021 and thereafter is expected to be subdued, curbing energy demand (see Figure H.2). Furthermore, the energy sector and its related industries are expected to be disproportionately affected by COVID-19.

According to IEA's World Outlook 2020, total energy demand does not return to its pre-crisis level until early 2023 and global CO2 emissions do not surpass 2019 levels until 2027.

31 https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-publications-and-technical-papers/nz-generation-data-updates/

32 This projection was finalised on the 28th of May 2021 and the GDP projection was based on Half-Year Economic and Fiscal Update 2020.

33 Since the release of HYEFU 2020, we have had two more quarterly GDP outturns. GDP rose 1.6% in the 2021 March quarter after a fall of 1.0 % in the previous quarter, which indicates that future economic growth could be highly volatile. However, near-term data suggests that the economy may grow stronger than predicted in the HYEFU 2020.

Figure H.1 Real GDP growth rate[34]

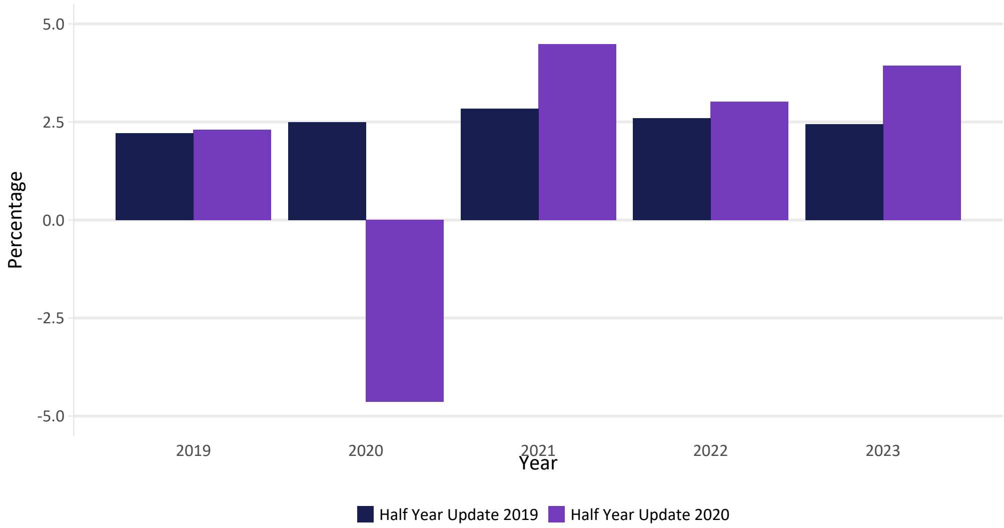
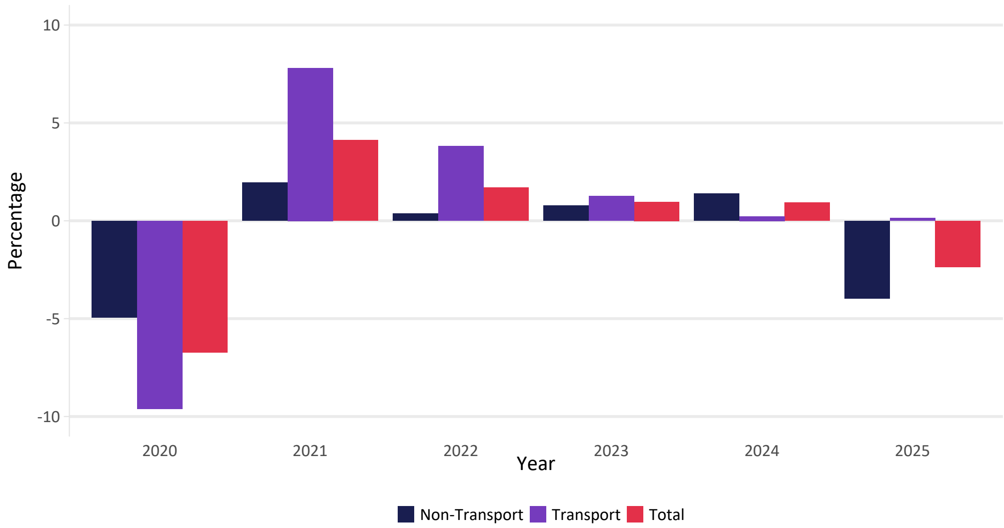


Figure H.2 Annual per cent change in final energy consumption



Non-transport component of energy demand is projected to be hit hard

In New Zealand, a relatively small number of energy intensive producing industries, which accounted for around 15 per cent of non-transport energy consumption before the pandemic, are expected to be hit hard by falling global energy prices. The energy intensive industries cover production of steel, aluminium, urea, methanol and oil products. In economics, the products produced by these industries are referred as hard commodities. In the past, the prices of the products produced by these industries are positively correlated with oil prices. In this projection, we assume that this relationship will continue to hold.

34 The Half Year Fiscal Updates are on the basis of June year and the forecast ends in June 2024 for the Half Year Update 2019. All graphs in this projection are on the basis of calendar year.

Dubai oil prices have rebounded to an average of USD$ 71 per barrel in June 2021 from USD$ 19 per barrel in late April 2020. Although recent gains in oil prices have taken away the extreme downside risk, oil prices are projected to remain subdued and return back to US$57 per barrel in 2025 according to oil future contracts prices.[35] In this projection, oil prices are assumed to reach USD$ 85 per barrel in 2040, which is USD$ 43 lower than assumed in EDGS 2019.[36]

The subdued oil price projections will lower commodity prices which in turn dampen the profitability of the energy intensive industries. Subsequently, these firms would either choose to lower their production or exit New Zealand.

As the border is not expected to fully open until the middle of 2023, Refining NZ is projected to slash its production to 70 per cent of its pre-COVID-19 level for the projection period, reflecting a sharp drop in demand for aviation fuel. There is also a possibility of closing the refinery and converting it into an import terminal in the near future.

In this projection, the closure of the Tiwai aluminium smelter is assumed to take place at the end of 2024. Closing Tiwai lowers electricity demand by around 12 per cent in 2024, which will bring forward the end of coal use for electricity generation. In this projection, we assume there are no potential replacement industries which could use the excess supply of electricity when Tiwai exits. Looking at the whole electricity system, the closure of Tiwai will reduce annual emissions from electricity generation by about 1.8 Mt CO_2e, assuming there is not significant new electricity demand to replace Tiwai. Taking into account non-energy emissions from the smelter, the closure will lower emissions by around 2.4 Mt CO_2e.

For methanol production, the Waitara Valley plant closed at the end of 2020. This equates to about 23 per cent of total methanol production in New Zealand.

Figure H.2 shows that non-transport energy demand continues to grow after COVID-19 and almost returns to its pre-COVID-19 level in 2024. But closing Tiwai will lower energy demand by 18 PJ, about 4.8 per cent of non-transport energy demand, in 2025 and thereafter.

Transport is projected to keep rolling

With traffic movements dropping significantly during the lockdown period in 2020, transport energy demand fell by around 9.6 per cent in 2020. Although the headline annual fall in transport energy is rather large in 2020, the most recent data for the December 2020 quarter shows that transport energy consumption was back to the same level of the previous December quarter.

Petrol road consumption

In order to understand the impact of COVID-19 on road transport, we need to have a better understanding of the factors that have driven the recent rebound in petrol consumption. To guide our thinking, we have attempted to separate transient impacts from longer-term changes, and quantify these over the budget periods. To shed light on the recent outturn, the direction and likely magnitude of these countervailing forces have been qualitatively and quantitatively evaluated. Three key areas of domestic tourism, flexible working and public transport are examined in further detail.

■ **Kiwi can't fly**

Border restrictions have effectively eliminated the option of overseas travel for New Zealanders post-lockdown. The remaining options available for people are to spend vacation time within their town/city or engage in domestic tourism. In order to support the struggling tourism sector, a number of public campaigns were launched to promote domestic tourism, including Tourism NZ's #DoSomethingNewNZ social media campaign. For the month of January 2021, domestic tourism spend was up by 24 per cent compared to January 2020.

International tourists have a very different transport activity profile compared to domestic tourists. The first group are much more likely to take flights and use coach buses, while locals are more likely to

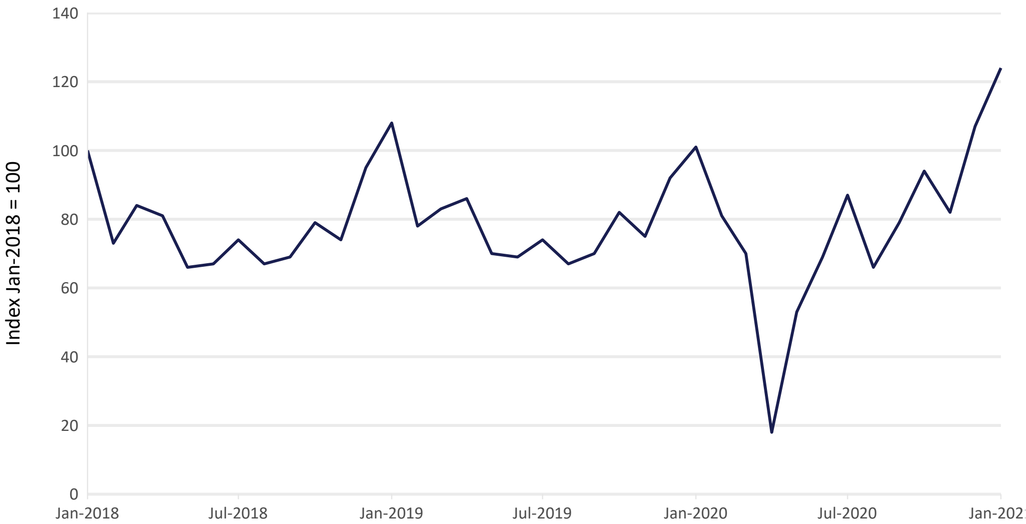
35 The figure is as of 22 July 2021 from https://www.cmegroup.com/markets/energy/crude-oil/light-sweet-crude.quotes.html#.

36 In EDGS 2019, the oil price projections are based on IEA World Energy Outlook 2018. The current projections are based on IEA World Energy Outlook 2020.

use their own vehicles. Therefore, the net impact of border restrictions might result in an increase in petrol demand.

According to the latest Tourism Electronic Card Transactions data (MBIE), domestic tourism fuel spend (adjusted for fuel price) was 14 per cent higher for the December quarter relative to the same quarter in 2019. All else being equal, this would result in around 2.4 per cent increase in total road petrol consumption. This represents an underestimate since activity of people taking shorter trips to neighbouring regions or within their own region will not be captured in the data if they refuel within ~40 km of their usual place of residence.

Figure H.3 Domestic tourism fuel spend index



■ **Working from home is becoming more normal**

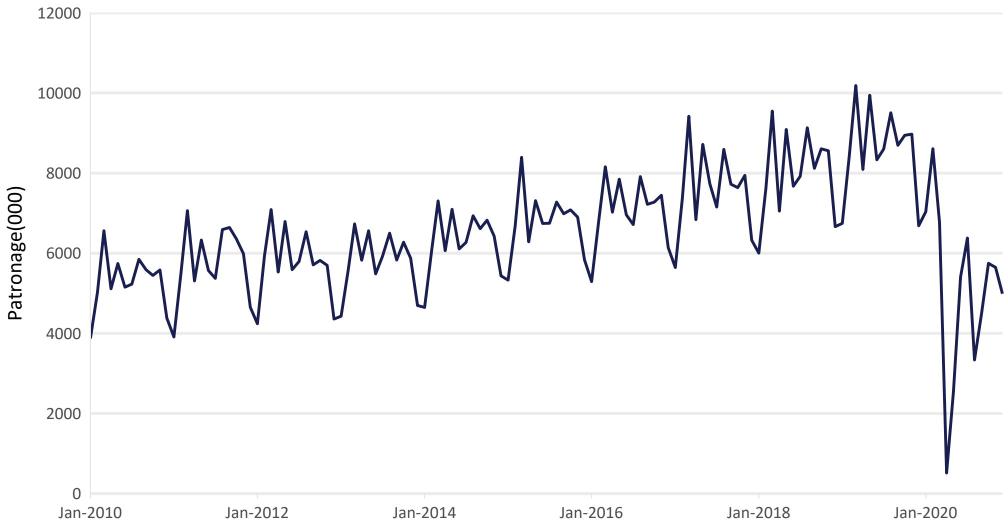
The latest update to the Household Labour Force Survey (December 2020 quarter) indicates a large and growing segment of the workforce usually work from home (WFH) at least some of the time. Over the six months to December 2020, this WFH segment increased by 14 per cent. This trend indicates a decrease in transport energy consumption from commuting for the year 2020, and is expected to be a factor in later years.

Almost half (48 per cent) of those who worked from home during the June 2020 quarter said this was not something they had always done in their current job. By the December quarter, this cohort had dropped to 23 per cent. Even after the return to level 1 conditions over the December quarter, average hours worked from home and median hours worked from home were 16.7 and 10.0 hours respectively.

■ **The COVID-19 pandemic has changed passenger behaviour**

Post-COVID-19 lockdown, public transport (PT) patronage numbers for both Auckland and Wellington are still significantly down on pre-COVID-19 levels. This large group of people who stopped taking PT are presumably still gainfully employed, and therefore are either WFH or taking private transport. Thus, this mode shift in transport could result in the rebound of road traffic.

Figure H.4 Total monthly patronage – Auckland transport



As a summary of the above three points, our main finding is that without the huge surge of domestic tourism, the consumption for the December quarter would have been around 5 per cent lower than usual. Our view is that the impact of domestic tourism on petrol consumption will wane over time, but other factors such as working from home will continue to exert its influences on transport activity.

Taken together, we surmise that the net impact of COVID-19 will lower vehicle kilometres for light passenger cars permanently by 2 per cent.

Furthermore, we also assume that there is no further lockdown, border restrictions are expected to be lifted gradually from the middle of 2021 and international tourism will not return its pre-COVID-19 level until 2025.

We expect transport energy consumption to rebound in 2021 after a sharp fall in 2020. We forecast transport energy to grow 7.8 per cent in 2021, followed by a growth of 3.8 per cent and 1.3 per cent in 2022 and 2023 respectively. Thereafter, demand for transport energy is expected to plateau for the next 4 years as the uptake of EVs (Electric Vehicles) increases gradually.

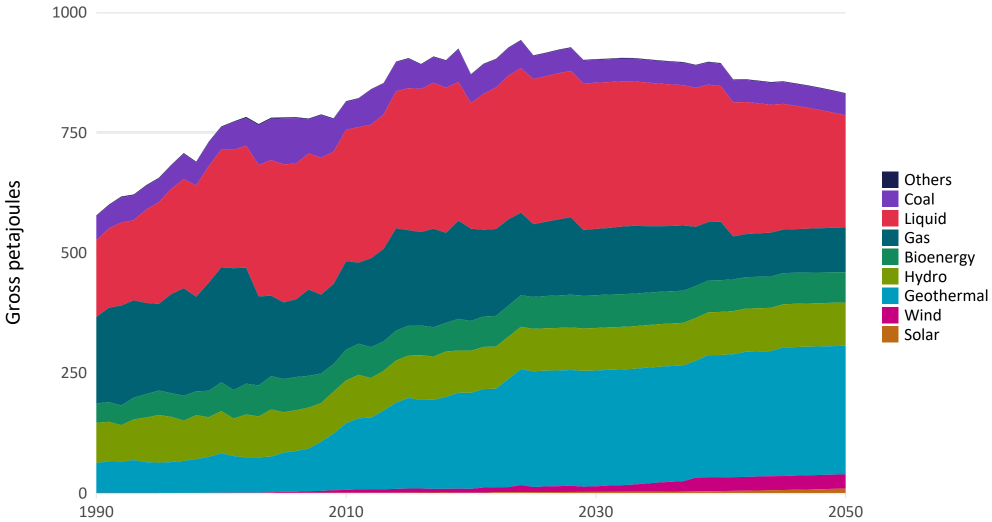
2. Long-term projections

Total primary energy supply has already reached its peak

Figure H.5 shows Total Primary Energy[37] Supply (TPES) which provides an overview of primary energy inputs required for the energy system in New Zealand. From 1990, primary energy has increased steadily, and geothermal energy and fossil oil have been the main source of growth. TPES peaked at around 925 PJ in 2019 and then declines slowly to 832 PJ in 2050 on average at an annual rate of 0.3 per cent per year.

37 Primary energy is an energy form found in nature.

Figure H.5 Total Primary Energy Supply

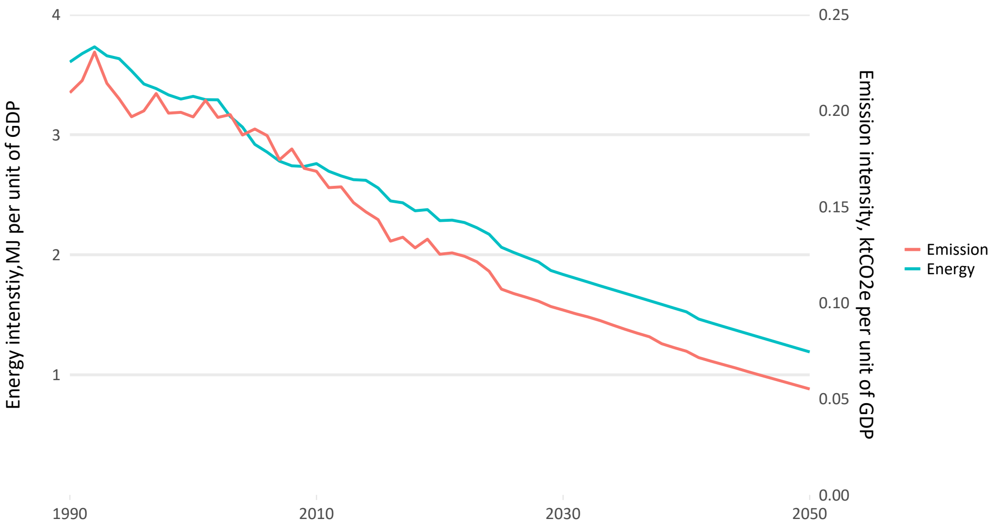


New Zealand economy becoming less energy-intensive

Energy intensity measures how much energy is required to produce a unit of GDP. There are three main factors that could affect this measure. The first one is related to the mix of goods and services we produce as a country. The second factor is driven by technology changes in energy efficiency. The third one is related to policy measures and behaviour changes.

Over the period from 1990-2019, the New Zealand economy was gradually transformed into a less energy-intensive economy. On average, we reduced our energy intensity by 1.4 per cent per year (see Figure H.6). Over the projection period, the rate of reduction in energy intensity is expected to increase to 2.2 per cent per year.

Figure H.6 Energy and emissions intensity

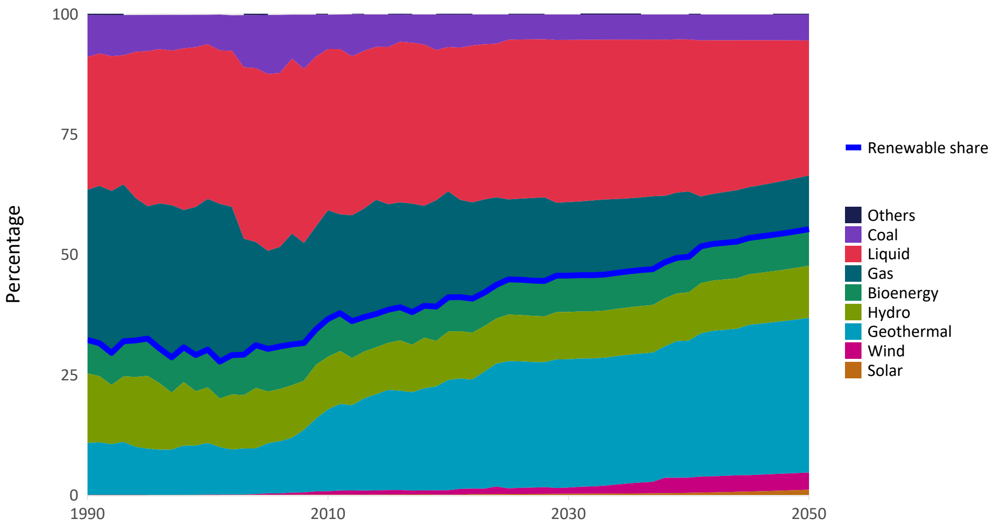


Renewable energy share of TPES is projected to increase

From an environmental perspective, not only is headline TPES a useful indicator, but each component of TPES plays a significant role in determining the final outcome of emissions. In particular, the percentage share of renewable energy of TPES gives us a picture of how sustainable New Zealand is.

Figure H.7 indicates that the renewable energy share of TPES was around 39 per cent in 2019 and increases to 46 per cent in 2035 in this projection. Therefore, there is room for New Zealand to further increase the renewable share of energy. It is important to note that these projections do not include assumptions about policies that are being developed to reduce energy emissions and support the uptake of renewable energy and energy efficiency in New Zealand. This means that the share of renewable energy in the future will likely be significantly higher than the level shown in this projection.

Figure H.7 Primary energy share by commodities



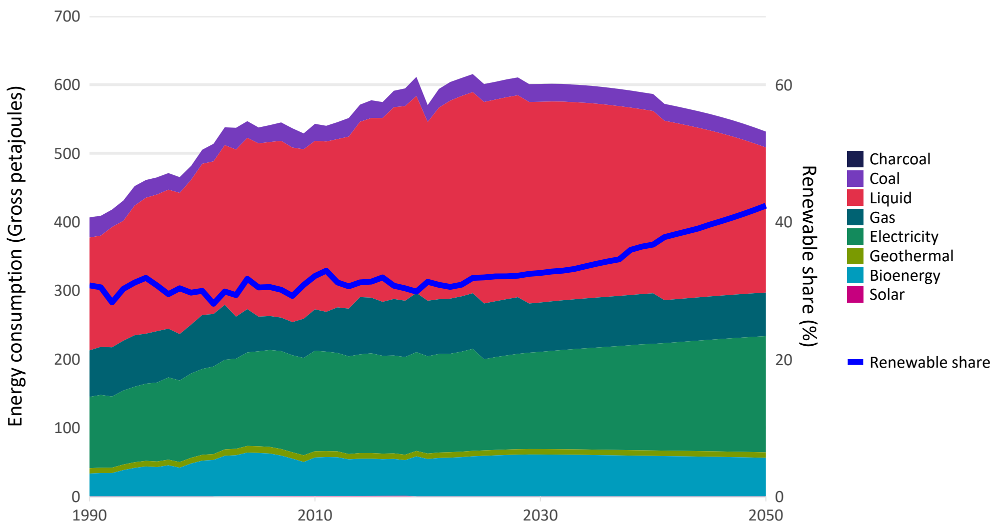
Renewable energy share of consumption is also projected to increase, but more slowly

In New Zealand, 95 per cent of geothermal energy was used for electricity generation in 2019. Geothermal energy has a very low conversion efficiency to electricity. As the share of geothermal energy increases, the renewable share based on TPES will overstate the true extent of renewable energy available for use in the economy. Analysing the renewable share of energy consumption would circumvent the issue of low conversion efficiency of geothermal energy and provides a useful complement to the TPES indicator. The share of renewable energy consumed in the economy has been smaller than the share of renewable energy derived from the supply side.

Figure H.8 presents final energy consumption by fuel type. From the consumption perspective, total energy demand also peaked at 611 PJ in 2019 and declines to 532 PJ in 2050 at an average rate of 0.4 per cent per year. Using the renewable share of electricity and final energy consumption by fuel type, we can estimate the renewable share of energy from the demand side.[38] Figure H.8 also shows that the share of renewable energy derived from the demand side is estimated to be 30 per cent in 2019, which is 9 percentage points lower than the estimate derived from the supply side. The renewable share of energy consumption reaches 34 per cent in 2035. The gap between the supply-side measure and the consumption-side measure widens to 12 percentage points by 2035.

38 Please note that this could also be referred to as the share of modern renewables in total final energy consumption. See Box A.1 at the end of the Overview Chapter. However, the historical renewable share in this projection is higher than the estimate in the Overview Chapter because there were some revisions in the dataset.

Figure H.8 Final energy consumption and its renewable share



The renewable share of electricity generation projected to reach 90 per cent in 2035

Electricity is considered as a secondary energy source because it is produced by converting primary sources of energy into electrical power. In 2019, about 35 per cent of primary energy was used to produce electricity.

In this projection, the share of electricity generation from renewable sources is projected to be around 90 per cent in 2035 compared with 81 per cent in 2019. The renewable share reaches 95 per cent in 2038 and remains at this level for the rest of the projection period. The remaining 5 per cent of non-renewable electricity generation from 2038 in the projection comes from gas fired generation which provides flexible supply, particularly in dry hydro periods. The projection does not assume investment in a renewable dry hydro year storage solution which would remove the need for the remaining flexible gas and coal fired generation in the projection. Options to provide renewable dry year storage are currently being investigated by the Government as part of the NZ Battery Project (see Box D.1 in the Electricity chapter for more about the NZ Battery Project). It is interesting to note that the renewable share electricity generation jumps to 94 per cent in 2025 after the closure of Tiwai.

Total energy emissions are projected to decrease

Emission intensity measures the amount of emissions per unit of GDP. Therefore, emission intensity is highly dependent on energy intensity. Figure H.6 shows that emission intensity declined almost at the same rate as energy intensity over the period from 1990 to 2008. Since 2008, emission intensity has fallen faster than energy intensity, which indicates that the economy has started to decarbonise using low-emission fuel.

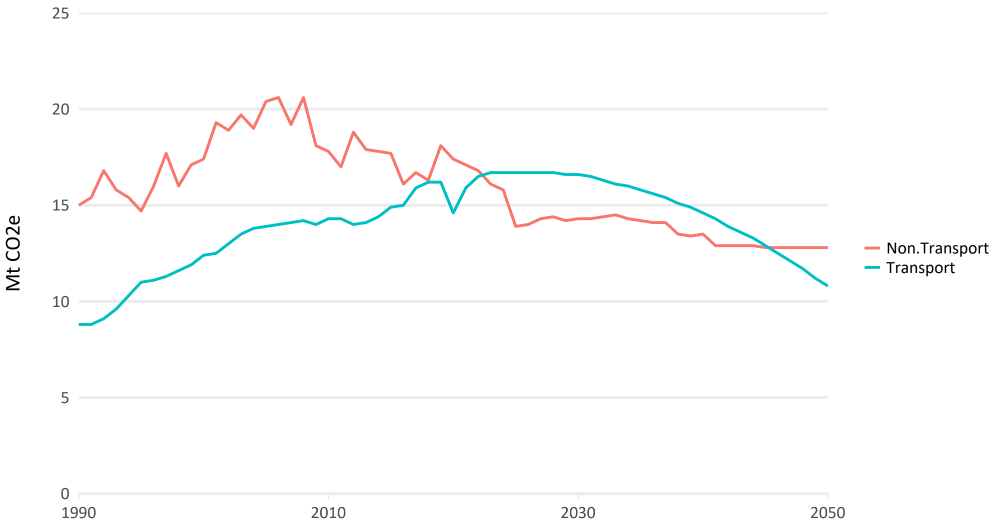
In this projection, the industrial and commercial sectors will continue to use less fossil fuel in their production process. We assume that about 8.8 PJ, which is equivalent to 8.7 per cent of fossil fuel used in process heat, and space and water heating in 2019 for the industrial and commercial sectors, will be electrified by 2050, the end of the projection period. This assumption is based on the amount of electrification that is economical at the assumed carbon prices of $35/ tCO2e and does not include any assumptions of new policies designed to shift process heat to renewable energy sources. Apart from the electrification of process heat, around 43 per cent of the light vehicle kilometres travelled and 12 per cent of the heavy vehicle kilometres travelled will be electrified by the end of 2050.

Total energy emissions are projected to decline from 34.3 Mt CO2e in 2019 to 30.0 Mt CO2e in 2035 and 23.6 Mt CO2e in 2050. Initially, non-transport emissions decline steadily, reflecting the continued growth in the less energy intensive portion of the economy and the uptake of new technology. As a result of the closure of Tiwai, non-transport emissions fall sharply in 2025.

Once both Methanex and Huntly unit 5 cease operation, there are limited opportunities for a large reduction in stationary energy emissions through decommissioning of individual operations. Furthermore, cost-effective emission reduction opportunities at the assumed carbon price of $35 /tCO2e, which come from electrifying low and medium heat, are mostly exhausted by 2040. As a result, non-transport energy emission stabilises at around 12.9 Mt CO2e for the last decade of the projection period as shown in Figure H.9.

After a strong recovery from the lockdown in 2021, transport emissions stabilize at around 16.7 Mt CO2e and decline gradually from 2030 onwards, reflecting the increasing impact of EV uptake.

Figure H.9 Energy emissions



3. Impact of carbon price on our forecasts

In the CCC (Climate Change Commission's) final report (2021),[39] CCC has suggested that a price of around $250 per tonne in 2050 would be required to achieve their recommended emissions budget levels. In this carbon price trajectory, carbon prices reach $84 per tonne in 2025, $138 per tonne in 2030 and $160 per tonne in 2035.

In this section, we explore the impact of carbon prices on emissions by using the same future carbon price trajectory as suggested by CCC in its recommendation. The sensitivity does not assume any additional policies to support emissions reduction. In our models, there is a perfect foresight economy. It means that every agent in the economy has a perfect prediction of future carbon prices and firms can plan their investment ahead to minimise their cost of operation. In reality, each agent has only partial information and will not make perfect predictions. Therefore, the models are likely to overestimate the impact of carbon prices on emissions. Instead of providing a single estimate, we provide a range to reflect the uncertainty of the impact of carbon prices on emissions. This range is show in orange in Figure H.10 for the non-transport sector and Figure H.11 for the transport sector. The lower bound of this range is generated directly from our suit of models and assumes perfect foresight. The upper bound of the range is generated by lowering the impact of higher carbon prices using our judgement on the impact of imperfect foresight and non-price barriers on fuel switching. In general, the width of the range represents the degree of uncertainty surrounding the impact of carbon prices.

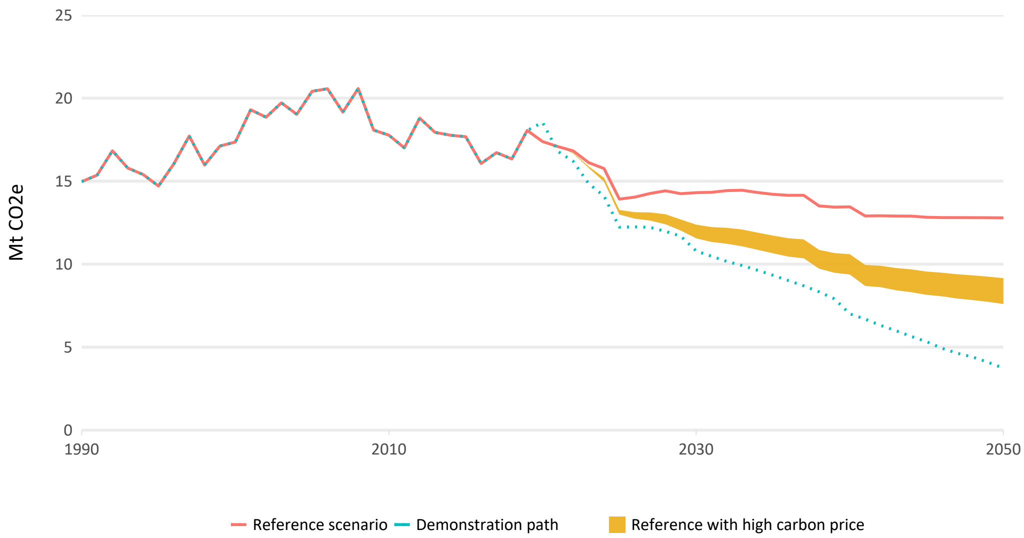
39 https://ccc-production-media.s3.ap-southeast-2.amazonaws.com/public/Inaia-tonu-nei-a-low-emissions-future-for-Aotearoa/Inaia-tonu-nei-a-low-emissions-future-for-Aotearoa.pdf Page 101

Overall, our modelling results suggest that carbon prices will play a significant role in reducing emissions for the non-transport sector. In particular, most low to medium process heat will be decarbonised through electrification or fuel switching to biomass.

The CCC's Demonstration path is an illustrative trajectory of emissions which would allow New Zealand to meet the CCC's recommended emissions budgets. Based on the sensitivity analysis we foresee a carbon budget shortfall of at least 5.5 Mt CO2e for meeting the CCC's recommended third budget (2031-2035) in the non-transport sector, based on the assumption that the carbon price will follow the CCC's price trajectory and that no additional policies will be put in place. This result highlights the role of additional policies to meet the CCC's recommended emissions budgets in the non-transport sector. Additional policies for meeting the first emissions budget and for setting New Zealand up to meet the next two budgets will be outlined through the Government's first emissions reduction plan, which will be in place by the end of 2021.

These additional policies will need to consider supporting emissions reductions from the sectors where either the abatement cost is higher than the carbon price used in the analysis, or where low-emissions technologies or infrastructure are not available.

Figure H.10 Impacts of carbon prices on the non-transport sector



Impact of the carbon price on the transport sector

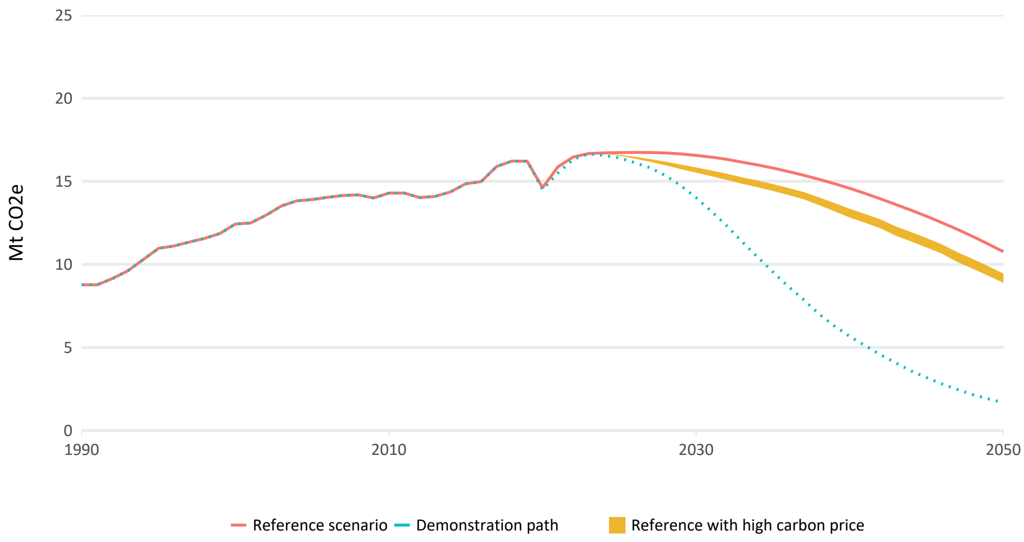
In New Zealand, EVs are still in the early phase of adoption, so we do not have enough data to estimate the impact of carbon prices on road transport emissions. Norway is an early adopter of EVs, and its experience provides valuable information on the factors that drive the demand of EV. Recently, a paper was published investigating fiscal policy measures affecting the prices of vehicles and fuel in Norway.[40] The paper found that energy prices have a considerable potential for changing the long term composition of the vehicle fleet and its energy consumption. In our modelling, we applied the elasticity values estimated in Norway to calculate the impact of higher carbon prices on road transport emissions. Although New Zealand has a different level of income and a different transport behaviour from Norway, it should provide a reasonable estimate of the impact of carbon prices, particularly at the early stage of EV adoption.

Figure H.11 provides the result of the sensitivity analysis for the transport sector. Overall, higher carbon prices lead to a modest reduction in emissions. However, carbon prices alone are unlikely

40 https://etrr.springeropen.com/articles/10.1186/s12544-020-00454-2

to reach emissions reduction required to meet the CCC's recommended emissions budgets as illustrated in the Demonstration path. This highlights both the role of additional policies to support emissions reduction in the transport sector and the ambitious target of the Demonstration path.

Figure H.11 Impacts of carbon prices on the transport sector



I: Glossary

Conversion equivalents between units of energy:

	PJ	TJ	GWh
Petajoule	1	1000	0.002778
Terajoule	0.001	1	0.2778
Gigawatt-hour	0.0036	3.6	1

Glossary

Abatement cost: The cost borne by firms when they are required to reduce greenhouse gas emissions created during production.

Black liquor: This is a recycled by-product formed during the pulping of wood in the paper making industry. It is burned in a boiler to produce useful heat and electricity. It is considered to be a solid biofuel.

Calorific value: Calorific value is the amount of energy released or produced during the combustion of a unit of fuel.

Capacity factors: The amount of electricity that was generated by a source over a period of time relative to the maximum amount that could have been generated based on its installed capacity.

Climate change commission: The Climate Change Commission is an independent Crown entity that advises the New Zealand Government on climate change action within the framework of the Climate Change Response Amendment Act

Coal types: Lignite, sub-bituminous and bituminous coal are all different types of coal. Lignite is the type which contains the least energy per unit of weight, followed by sub-bituminous and then bituminous. They have different uses because of this. For example, bituminous coal is used as a coking coal, whereas sub-bituminous coal is used for electricity generation.

Cogeneration: Otherwise known as combined heat and power, is the use of a heat engine or power station to generate electricity and useful heat at the same time. This useful heat is used for applications like industrial boilers or space and water heating.

Conversion efficiency: The ratio between the useful output of an energy conversion machine (eg. a geothermal generator) and the input, in energy terms.

Conversion losses: The energy lost in the transformation of energy. This is calculated as the difference between the input and output energy.

COVID-19 Alert Levels: More information can be found here: covid19.govt.nz

Direct use: The consumption of fuel by a user. This excludes any energy used for transformation into another form of energy, for example combustion of coal for the generation of electricity.

Energy commodity: Any tradeable form of energy.

Energy Efficiency and Conservation Authority: EECA was established as a Crown entity under the Energy Efficiency and Conservation Act 2000 to encourage, promote and support energy efficiency, energy conservation and the use of renewable sources of energy.

Essential businesses: Businesses that are essential to the provision of the necessities of life and those businesses that support them, as described on the Essential Services list on COVID.govt.nz

Feedstock: A raw material to supply or fuel a machine or industrial process

Generation capacity: The maximum level of electricity that a power plant can supply at a specific point in time under certain conditions.

Indigenous production: The production of primary energy within New Zealand

Modern renewables: This includes all renewable fuels, and in some cases biomass use as well. For developed countries, all biomass use is assumed to be 'modern' while for developing countries only the portion of energy use that is not used by households is considered to be 'modern'.

Non-energy use: Covers those fuels that are used as raw materials in the different sectors and are not consumed as a fuel or transformed into another fuel. Non-energy use is shown separately in final consumption under the heading non-energy use. Note that for biofuels, only the amounts specifically used for energy purposes (a small part of the total) are included in the energy statistics. Therefore, the non-energy use of biomass is not taken into consideration and the quantities are null by definition

Peaking plant: Power plants that generally run only when there is a high demand, known as peak demand, for electricity. They are generally built to generate electricity from natural gas.

Primary energy: The amount of potential energy in a unit of fuel. This is often more than the total energy that is used in that fuel, but never less.

Process Heat: The energy used as heat mainly by the industrial and commercial sectors for industrial processes, manufacturing and space heating. This is often in the form of steam, hot water or hot gases.

Renewables: In our statistics, the fuels considered as renewables are:

- Solar
- Wind
- Hydro
- Geothermal
- Biofuels

  This excludes those renewables we don't have data on in New Zealand (e.g. Tidal energy)

Sensitivity analysis: the study of how the uncertainty in the output of a forecasting model or other system can be allocated to different sources of uncertainty in its inputs

Stock changes: Reflects the difference between opening stock levels on the first day of the year and closing levels on the last day of the year of stocks on national territory held by producers, importers, energy transformation industries and large consumers. A stock build is shown as a negative number, and a stock draw as a positive number.

Thermal electricity generation: generation using thermal energy sources. Thermal energy sources include gas, coal, oil, and in some cases of cogeneration, solid biofuels.

Transformation process: The conversion of primary forms of energy to secondary and further transformation (e.g. coking coal to coke, crude oil to oil products, and fuel oil to electricity). Inputs to transformation processes are shown as negative numbers and output from the process is shown as a positive number. Transformation losses will appear in energy statistics as negative numbers.

Transmission and distribution losses: Energy losses in transmission between sources of supply and points of distribution and in the distribution to consumers

Transpower: The state-owned enterprise responsible for electric power transmission in New Zealand.

Woody biomass: In this report woody biomass refers to biomass produced from woody materials. That includes, but is not limited to: sawdust, shavings, paper, wood pellets, black liquor, charcoal and firewood. In MBIE's statistics there are currently no solid biofuels that are not considered as woody biomass.

J: Methodological improvements and revisions

As part of its commitment to statistical quality, MBIE regularly reviews the methods it uses for producing statistics on energy supply, demand, prices, and emissions. This section gives a summary of significant methodological updates that were implemented for this edition of Energy in New Zealand, as well as notable revisions to previously published data.

For an overview of the data sources and methods currently used by MBIE to produce national energy statistics, please consult the latest version of the Energy statistics sources and method paper.[41]

Direct use of renewables

Industrial solid biofuels use revisions

MBIE produces statistics on use of solid biofuels using a range of sources. Solid biofuels include wood residuals, black liquor,[42] and charcoal.

The main source used to estimate industrial use of solid biofuels Scion's Wood Processing Database, which is a database of wood processors in New Zealand. This covers the majority of large-scale wood processors in the country and contains a range of information, including estimates of energy demand at sites.

Scion was commissioned to provide MBIE with an updated version of the database in early 2021. This was incorporated into MBIE's statistics and resulted in revisions to the full time series of estimated use of solid biofuels in New Zealand.

As well as incorporating this updated data, MBIE also reviewed its classification of energy use (covering both end-use and use for cogeneration) in the wood, pulp, and paper sectors to ensure its alignment with the International Energy Agency's reporting framework. This resulted in the discovery that black liquor use should be classified as cogeneration use rather than end-use as it feeds into cogeneration systems as pulp mills.

While some methods exist to allocate fuel use at cogeneration plants to the production of electricity and heat, a lack of the necessary data for many sites limits the ability to do this so all fuel use at cogeneration plants is allocated to energy transformation. As a result, black liquor was reclassified from consumption by end-users in the industrial sector to cogeneration use for energy transformation purposes.

Residential wood use revisions

Following each Census of Population and Dwellings, MBIE will update figures for residential firewood use using the Census value for the proportion of households that use firewood. However, MBIE has adjusted the method for calculating firewood so that firewood use is held constant for all periods after the latest Census, instead of being scaled by Occupied Dwelling statistics. The method for calculating firewood use in periods previous to the latest census remains the same.

Electricity generation

As well as the reallocation of black liquor use to cogeneration use, as outlined above, there were several other revisions to MBIE's electricity generation statistics in the preparation of this edition of Energy in New Zealand.

There were revisions to electricity generated from geothermal sources due to adding generation plants that were previously missing from MBIE's statistics. Additionally, there were revisions to electricity generation and plant capacities data from incorporating updated data that we received.

Coal

All coal produced in New Zealand since the March quarter 2017 has been in opencast mines. However a misclassification meant that some coal production was being classified as underground. MBIE has corrected this with all coal production from underground mines for 2017 onwards being reclassified as opencast.

41 https://www.mbie.govt.nz/assets/Energy-statistics-sources-and-methods.pdf

42 Black liquor is a byproduct of the kraft pulp process and is combusted in a recovery boiler to generate electricity and heat for industrial processes.

Oil and Gas

Oil stock revisions

Stock levels for petrol and diesel were revised from 2019 onward due to updated data from data suppliers. Some suppliers had been counting inventories that are not considered stocks under IEA rules, and this required revising our stock for these products down.

Oil consumption revisions

Oil consumption is calculated by combining quarterly data from major fuel retailers (Delivery of Petroleum fuel by Industry, or DPFI), and annual data from smaller retailers (Annual Liquid Fuels Survey or ALFS).

Due to COVID-19 a representative set of ALFS data could not be captured for 2019, so 2018 proportions were carried forward. Now that we have a complete set of data for 2020, the gaps in 2019's data can be interpolated, allowing for updated 2019 consumption figures.

The revisions have changed the sectoral allocation of liquid fuels, but not the overall consumption levels. The effects were most pronounced with sectors that are primarily served by smaller retailers, such as agricultural diesel consumption.

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