Environmental-economic accounts: 2019

Data to 2017

1 July 2019: We've made corrections to figures 5 and 30.

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Executive summary

Environmental-economic accounts: 2019 (data to 2017) presents the relationships between the environment and the economy, and the stocks, and changes in stocks, of New Zealand's natural resources.

This edition of the accounts focuses on climate change and the transition to a low-emissions economy: the pressures of emissions on the atmosphere, the likely impacts of climate change on natural resources, and the extent of economic responses to reduce emissions.

Climate change

Climate change is one of the most important environmental challenges globally, with enough evidence showing greenhouse gas emissions from human activities are causing this (Intergovernmental Panel on Climate Change (IPCC), 2013).

Concentrations of carbon dioxide in the atmosphere are at their highest in 400,000 years. This is expected to affect the availability and demand for natural resources, and increase the rate of loss of biodiversity and ecosystems that provide services essential for life (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2019).

Countries are seeking to reduce greenhouse gases in response to the Paris Agreement of December 2015. To do this they need robust data on the sources of emissions that contribute to climate change, and information on the impacts of climate change on the environment.

The aim of the Paris Agreement is to hold the increase in the global average temperature to well below 2 degrees Celsius above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5 degree Celsius above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change.

Greenhouse gas emissions stem from all parts of the economy as well as direct activities by households. The Climate Change Response (Zero Carbon) Amendment Bill will introduce new targets to reduce all greenhouse gases (except biogenic methane) to net zero by 2050 but levels of gross emissions are unchanged in the last decade and the rate of new planting in forestry has slowed. Moving to a low-emissions economy will require a combination of reduced emissions from industry and households, and land use changes.

Environmental-economic accounts

The environmental-economic accounting approach can inform discussions around climate change by linking environmental, economic, and social data. It brings together economic and environmental information, enabling us to talk about the environment in the same language as economics. This is particularly important as New Zealand transitions to a low-emissions economy. Information from the accounts can show trade-offs from the transition, adaptive actions, and impacts on the economy and environment.

We combined the latest estimates from the environmental-economic accounts to provide information on drivers, pressures, impacts, and responses, which complement information on the state of the atmosphere and climate provided by the Environmental reporting series. We provide estimates on greenhouse gases by industry and households, timber stocks and changes in stocks, carbon sequestration, and environmental taxes. Climate change will affect New Zealand's natural resources, so we show how the benefits we get from natural resources will be recorded in the environmental-economic accounts. We discuss critical data gaps that may affect the environment-economy linkages in relation to climate change.

New Zealand’s greenhouse gas emissions

Most Annex I countries reduced their greenhouse gas emissions from 2008-15. New Zealand’s emissions decreased 0.8 percent over the 2008-15 period, but this is among the smaller decreases observed.

The structure of New Zealand’s economy and its dependency on the primary sector for exports affect its emissions intensity, which was 11th highest among 31 countries in 2015. New Zealand’s carbon dioxide intensity ranked 21st highest among 31 countries. The difference between these reflects the significant contribution of methane to New Zealand’s emissions profile.

Household emissions

Emissions from households rose 19.3 percent from 2007–17 mainly due to road transport. Compared with industry emissions, household emissions increased at a faster rate as reflected in its contribution to total emissions, which rose from 9 percent to 11 percent over the period. This increase was faster than the increase in the number of households (up 9.7 percent over the period), which implies that households have been less efficient at managing direct emissions since 2007.

New Zealand is 1 of 10 (out of 38) countries that has seen production of emissions by households increase since 2008–15. This report identifies that the contribution of households to emissions can be more fully understood by measuring emissions from a consumption perspective.

Tourism emissions

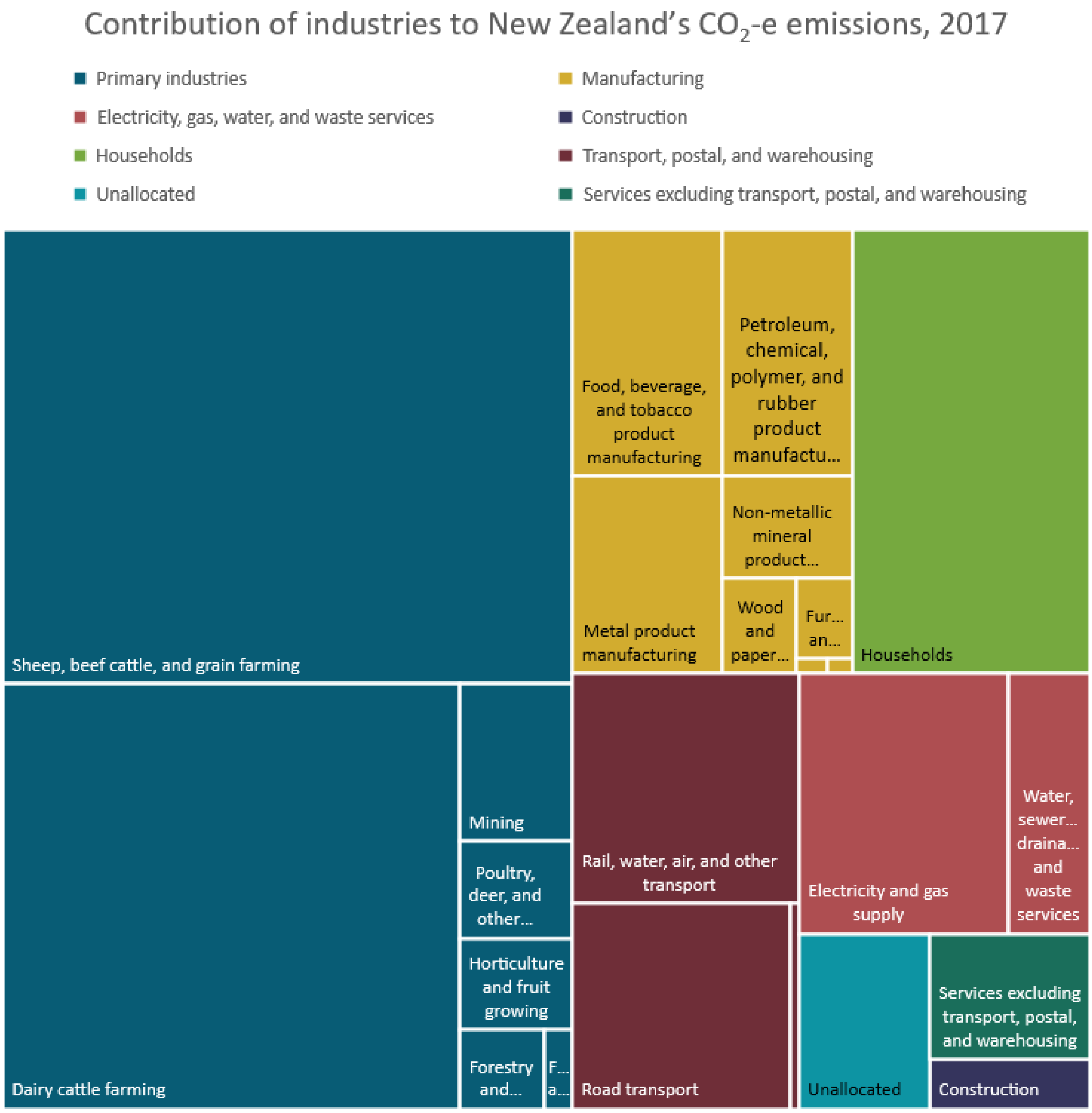
Emissions from road transport have also been increasing due to the higher number of tourists using road transport. Road transport emissions from international tourists in New Zealand rose 19.3 percent over 2007–17, amounting to 7.8 percent of total road transport emissions in 2017. Tourists use mainly diesel for their fuel. Diesel has a higher emissions factor than petrol, and a higher relative contribution to emissions per dollar spent. Total emissions from international tourists increased 20.0 percent over the period. The emissions intensity of tourism (emissions in relation to tourists’ average length of stay) also increased over the period.

Industry emissions

Main contributors to 2017 emissions

In 2017, the main industry contributors to total emissions were sheep, beef cattle, and grain farming; dairy cattle farming; electricity and gas supply; and transport (figure 1). Emissions from industry accounted for 89 percent of total emissions in 2017, with households accounting for a further 11 percent.

Figure 1

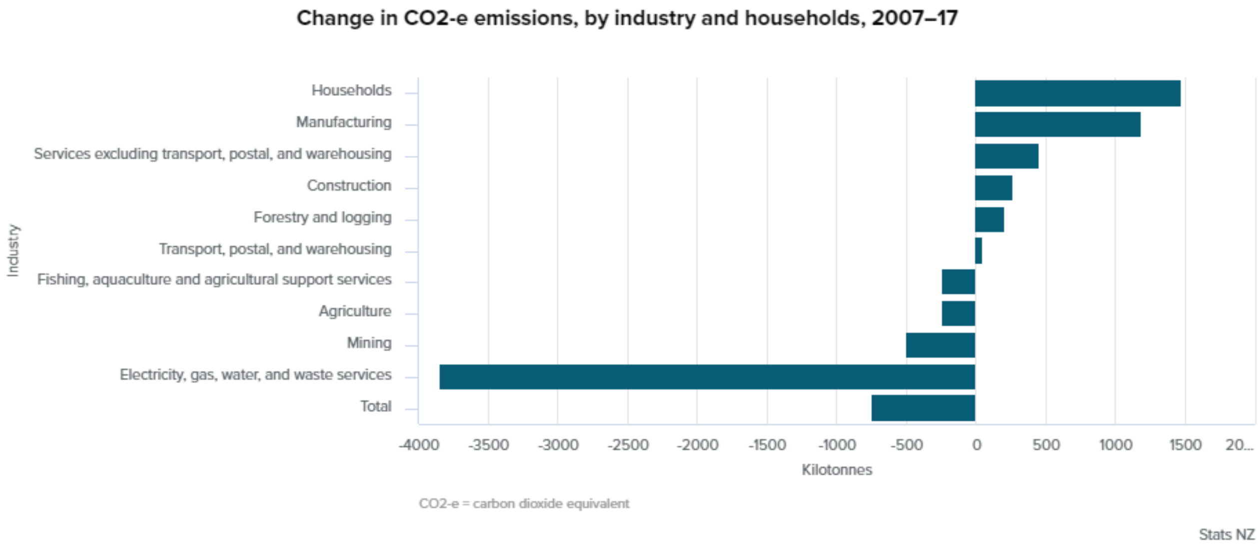


Source: Stats NZ

Change in emissions over 2007–17

Total industry emissions decreased 2.9 percent from 2007–17, driven mainly by the electricity, gas, water, and waste services industry (figure 2). This decrease was achieved while the industry's economic activity continued to grow, and was partly attributable to increased use of renewable energy sources.

Figure 2



Mining and agriculture also contributed to the reduced industry emissions from 2007–17. However, much of these reductions were offset by increases from households and manufacturing, as well as services, construction, forestry, and transport.

From 2007–17, total industry emissions decreased 2.9 percent (or 2,217 kilotonnes), with decreases coming from:

- electricity and gas supply – down 41.7 percent (3,359 kilotonnes)
- sheep, beef cattle, and grain farming – down 11.7 percent (2,969 kilotonnes)
- poultry, deer, and other livestock farming – down 43.6 percent (727 kilotonnes)
- mining – down 24.6 percent (497 kilotonnes)
- water, sewerage, drainage, and waste services – down 20.9 percent (485 kilotonnes)
- non-metallic mineral product manufacturing – down 28.5 percent (456 kilotonnes)
- rail, water, air, and other transport - down 8.8 percent (437 kilotonnes)

However, emissions increased for:

- dairy cattle farming– up 27.7 percent (3,636 kilotonnes)
- petroleum, chemical, polymer, and rubber product manufacturing – up 63.1 percent (1,069 kilotonnes)
- food, beverage, and tobacco product manufacturing – up 44.8 percent (984 kilotonnes)
- road transport – up 16.5 percent (548 kilotonnes)
- services excluding transport, postal, and warehousing – up 36.0 percent (460 kilotonnes)
- construction – up 65.9 percent (272 kilotonnes)
- forestry and logging – up 54.1 percent (203 kilotonnes).

Table 1 summarises the contributions of broad industry groups and households to emissions in 2017, the change in emissions from 2007–17, and average growth rates for key gases.

Table 1

Contribution, change, and annual growth of emissions by broad industry group and households, 2007-17

Industry (ANZSIC06) and households	2017	2007–17			
			Key gases		
	Contribution to total CO_2-e	Change in CO_2-e	CO_2-e	CO_2	Methane
	% of total	Kilotonnes	Average annual % change		
Primary industries	52.4	-771	-0.2	-1.5	-0.2
Goods-producing industries	21.7	-2,380	-1.2	-1.2	-1.7
Service industries	12.4	506	0.5	0.4	-5.5
Total all industries	89.0	-2,217	-0.3	-0.8	-0.2
Households	11.0	1,473	1.8	1.8	0.1
Total	100.0	-744	-0.1	-0.2	-0.2

Note: $CO_{2\text{-}e}$ – carbon dioxide equivalent

Source: Stats NZ

Agricultural emissions

This report contains new estimates of emissions from the agricultural industries. Industries within agriculture include: horticulture and fruit growing; sheep, beef cattle, and grain farming; dairy cattle farming; and poultry, deer, and other livestock farming.

Sheep, beef cattle, and grain farming accounted for over half of emissions from the agriculture industry and 27.1 percent of total emissions in 2017, making it New Zealand's largest-emitting industry. The decline in emissions from the sheep, beef cattle, and grain farming industry was the second largest of all industries from 2007–17. While sheep and beef numbers, and their emissions, declined, increased dairy activity offset these reductions. Dairy cattle farming was the only agriculture industry to record an increase in emissions from 2007–17, up 2.5 percent a year, and had the largest increase in kilotonnes of all industries. Dairy cattle farming accounted for 20.3 percent of total emissions, similar to the proportion of emissions from the manufacturing, and electricity and gas supply industries combined.

Emissions and economic activity

From 2007-17, agriculture emissions decreased at a rate of 0.1 percent a year (although no significant trend could be observed) while its contribution to GDP (in real terms) grew at a rate of 1.8 percent a year.

Other industries to show a reduction in emissions relative to their contribution to GDP included the transport, postal, and warehousing industry (emissions up 0.1 percent a year, but contribution to GDP grew 3.0 percent a year) and mining (where emissions fell 2.8 percent a year but contribution to GDP fell 0.8 percent a year). However, emissions increased at a faster rate than the contribution to GDP (in real terms) for:

- forestry and logging
- construction

- manufacturing
- services excluding transport, postal, and warehousing.

Manufacturing's emissions increased 1.2 percent a year and was the main emitter of carbon dioxide in 2017. Within manufacturing, some industries contributions to both GDP and emissions decreased, others showed absolute decoupling (contribution to GDP increased while emissions decreased), while others showed emissions increasing faster than GDP.

Net emissions

From 1990–2017, New Zealand's gross emissions as measured in the Greenhouse Gas Inventory (Ministry for the Environment (MfE), 2019) increased 23.1 percent.

Net emissions (which accounts for the land use, land-use change, and forestry sector) increased 64.9 percent over the same period, mainly due to increases in both harvesting from plantation forests and in gross emissions.

Understanding the extent and capacity for forestry to offset gross emissions is essential for tracking progress towards net emissions targets. Carbon sequestration in cultivated forests declined over the last decade (down 19 percent from 2007–17) largely due to increased rates of harvesting, along with reduced rates of planting, and deforestation. This report discusses how the use of timber products in the economy, as well as the rates of timber harvest, is important for tracking progress towards a low-emissions economy.

Responding to climate change

The Emissions Trading Scheme is New Zealand's main policy response for reducing greenhouse gases. The scheme places a price on greenhouse gases to encourage emitters to implement emissions-reducing technologies. Understanding the distribution of permits across industries is an area for future focus. However, environmental taxes on energy and transport have been increasing and higher-emitting industries on average pay higher environmental taxes. The extent to which subsidies are used in New Zealand remains an area for future development. Assessing the range of taxes, subsidies, and permits by industry, along with emissions, will provide a means to track our responses to climate change and how we are progressing towards a low-emissions economy.

Purpose and background

Environmental-economic accounts: 2019 (data to 2017) provides a record of New Zealand's stocks and flows of natural capital (environmental assets), the flows of pollutants from the economy to the environment, and the economic activities undertaken to protect the environment.

This report focuses on climate change and New Zealand's transition to a low-emissions economy. This thematic approach shows how environmental-economic accounts can be integrated and used to inform this issue.

We compiled the information using the System of Environmental-Economic Accounting (SEEA) framework, which the United Nations adopted in 2012 as the international standard for measuring the interactions between the environment and the economy.

Background to environmental accounting

Stats NZ produces the following environmental-economic accounts using the SEEA framework:

- physical stocks of land cover, timber, and water
- monetary stocks of timber, fish, and renewable energy resources
- annual resource rents for fish, timber, minerals, and renewable energy
- physical flows of greenhouse gases by industry and households
- environmental protection expenditure by central and local government, and environmental taxes.

We also produce estimates of the marine economy in terms of gross domestic product (GDP) and persons employed.

Most of these accounts are updated annually. We update tables every February to take advantage of data available in late November, and publish more tables in June each year using data available in April. Source data for the land and water accounts is not available annually, so we update these accounts approximately every three to five years or as data becomes available and funding allows.

Environmental-economic accounts: 2018 was the first in a new series of SEEA accounts in New Zealand. The report included discussion and results for all the tables released to February 2018.

SEEA is an internationally accepted statistical standard that specifies how environmental and economic information can be integrated coherently. It uses the concepts, definitions, and classifications consistent with those in the System of National Accounts (SNA), which Stats NZ uses to produce economic statistics such as GDP. The SEEA framework allows us to make direct comparisons between environmental and economic information, so that we have a clearer understanding of environmental-economic trade-offs and a more complete picture of our country's economic and environmental performance.

Environmental-economic accounts: sources and methods has further information on the definitions, concepts, sources, and methods we used to compile the accounts. There are numerous gaps in our data which we intend to fill over time. We encourage you to provide feedback and suggestions for future developments to environmental.accounts@stats.govt.nz.

Developments since Environmental-economic accounts: 2018

We made the following improvements to how we measure greenhouse gases by industry and households (referred to in the 2018 report as the air emissions account):

- additional industry disaggregation for:
    - agriculture – horticulture and fruit growing; sheep, beef cattle, and grain farming; dairy cattle farming; poultry, deer, and other livestock farming
    - electricity, gas, water, and waste services – electricity and gas supply; water, sewerage, drainage, and waste services
    - transport, postal, and warehousing – road transport; rail, water, air, and other transport; postal, courier transport support and warehouse services
- additional detail for households – transport; heating/cooling; other
- additional gases – hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride
- adjustments for economic residence:
    - estimates of direct emissions from road transport by international tourists
    - emissions by New Zealand residents overseas.

We produced an experimental carbon stock in the timber account. We also incorporated improved measures of indigenous timber stocks using data from the Land Use and Carbon Analysis System.

We improved the presentation of environmental taxes by showing the share of environmental taxes in relation to tax type.

We are now reporting on the number of wage and salary earners rather than filled jobs in the marine economy. The reference period for the marine economy is the year ended March, and job counts tend to correspond to short reference periods such as quarterly and monthly.

Revisions to previously published accounts has more information on changes to input data sources.

Climate change and the transition to a low-emissions economy

Climate change is one of the most important environmental challenges globally, with enough evidence showing greenhouse gas emissions from human activities are causing this (IPCC, 2013).

Levels of atmospheric carbon dioxide measured at Baring Head near Wellington (internationally recognised site for global climate change and atmospheric impact studies) increased 23 percent from 326 to 401 parts per million between 1972 and 2016 (MfE & Stats NZ, 2017). This level now exceeds the symbolic threshold of 400 parts per million (NASA, 2017b), the highest level in our atmosphere in at least the last 800,00 years (IPCC, 2013). The value of 400 parts per million is required to limit global temperature increases and other climate change impacts (MfE & Stats NZ, 2017).

Many significant changes in New Zealand's climate have already been observed across the country, but regional variations can also be seen, particularly for rain and snow fall. Changes include alterations to temperature, precipitation patterns, sea-level rise, glacier ice storage, wind and sunshine, and ocean acidification (MfE & Stats NZ, 2019).

New Zealand's annual average temperature increased 1 degree Celsius between 1909 and 2016. Four of the last six years were among the warmest on record (NIWA, 2018). The average annual temperature has not been this warm in the past 10,000 years, which is likely to be near or already outside the range that humans and current ecosystems have experienced (MfE, 1997).

Climate change is already affecting New Zealand, and the effects will intensify with time. For some impacts, such as extreme rainfall events, changes to the baseline have not yet been detected. Other impacts, such as rising sea levels, are already significantly different from pre-industrial conditions.

Environment Aotearoa 2019 reports on some of the key impacts:

- changes in the availability and demand for water resources
- increased risk of extreme fire conditions
- effects on marine ecosystems and fish stocks
- risks to infrastructure from increased extreme weather events
- economic impacts on agriculture, horticulture, and tourism.

Transition to a low-emissions economy

The Climate Change Response (Zero Carbon) Amendment Bill provides a framework by which New Zealand can develop and implement clear and stable climate change policies. This response contributes to the global effort under the Paris Agreement, which seeks to hold the increase in the global average temperature to well below 2 degrees Celsius above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5 degree Celsius above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change.

The Bill has four key elements:

- Set a new greenhouse gas emissions reduction target, to:
  - reduce all greenhouse gases (except biogenic methane) to net zero by 2050
  - reduce emissions of biogenic methane to at least 24–47 percent below 2017 levels by 2050, including to 10 percent below 2017 levels by 2030.

- Establish a series of emissions budgets to act as stepping stones towards the long-term target.
- Require the Government to develop and implement policies for climate change adaptation and mitigation.
- Establish a new, independent Climate Change Commission to provide expert advice and monitoring, to help keep successive governments on track to meeting long-term goals.

Environmental-economic accounting and climate change

Countries are seeking to reduce their greenhouse gas emissions in response to the Paris Agreement of December 2015. To do this, they need robust data on the sources of emissions that are putting pressure on our environment, and on the impacts of and responses to climate change.

The 24th Meeting of the Conference of Parties in 2018 outlined the need for strengthening statistical systems to support policy related to climate change. These systems include those for measuring emissions in greenhouse gas inventories, adaptation, and financial transactions.

The environmental-economic accounting approach is one such statistical system that can inform discussions around climate change, particularly by linking economic and social data. It brings together economic and environmental information, and permits us to talk about the environment in the same language as economics. It can complement other environmental statistics, particularly those relating to the state of the atmosphere and climate as produced by the Environmental reporting series.

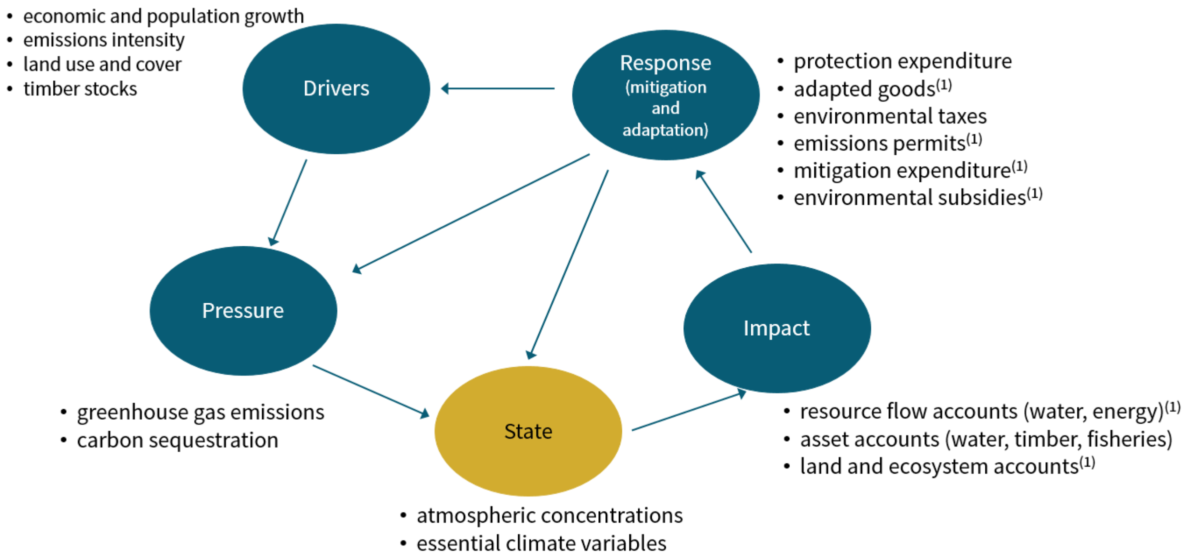
Driver-pressure-state-impact-response framework

There is high demand for good statistics that can support the measurement and analysis of the drivers of the social and economic consequences of climate change, and the related mitigation and adaptation measures (UN, 2008, as cited in Schenau, 2009).

Figure 3 shows which accounts from the environmental-economic accounting framework provide information on the drivers, pressures, impacts, and responses that can complement information on the state of atmosphere and climate (eg concentrations of emissions, temperature, and weather events) available through environmental reporting (MfE & Stats NZ, 2017).

Figure 3

Environmental-economic accounts for climate change in a DPSIR framework



1. Data not available.
Note: DPSIR – drivers, pressures, state, impact, and response model of intervention
Source: Stats NZ

Pressures on the atmosphere and climate stem from greenhouse gas emissions, which are driven by economic activity, population changes, and land use choices (figure 3). The resulting concentrations of atmospheric pollutants determine changes in climate, which may in turn affect economic activity through drought, changes in growing conditions, and availability of natural resources. Societal responses can be measured in the SEEA by assessing the extent and distribution of environmental taxes, emissions permits, and fossil fuel subsidies.

The following Stats NZ accounts enable connections between pressure, impact, and response to be drawn.

- greenhouse gases by industry and households
- timber physical asset and carbon accounts
- environmental taxes.

Greenhouse gases by industry and households

Estimates of greenhouse gas emissions by industry and households use data from MfE's Greenhouse Gas Inventory to show which industries are contributing to emissions, as well as the direct contribution of households. It also separates the contribution of non-residents and identifies the impact of New Zealand's activities overseas.

Timber physical asset and carbon accounts

The timber physical stock account presents information on the timber stocks available and not available for wood supply, with monetary values of the stock available for exotic stocks. The timber accounts relate closely to carbon stock accounts and the ecosystem services of carbon sequestration and storage. Changes in timber stocks, from additions and removals, affect carbon sequestration and therefore, the net flow of greenhouse gases to the atmosphere.

The accounts can be used to understand the drivers or impacts of climate change: availability and harvest of timber stocks can inform on pressures of atmospheric state, while losses of timber due to increased number of fires from climate change will also be recorded in the timber stock account.

Measuring emissions: production and consumption perspectives

Three main approaches are used to measure greenhouse gases at the national level:

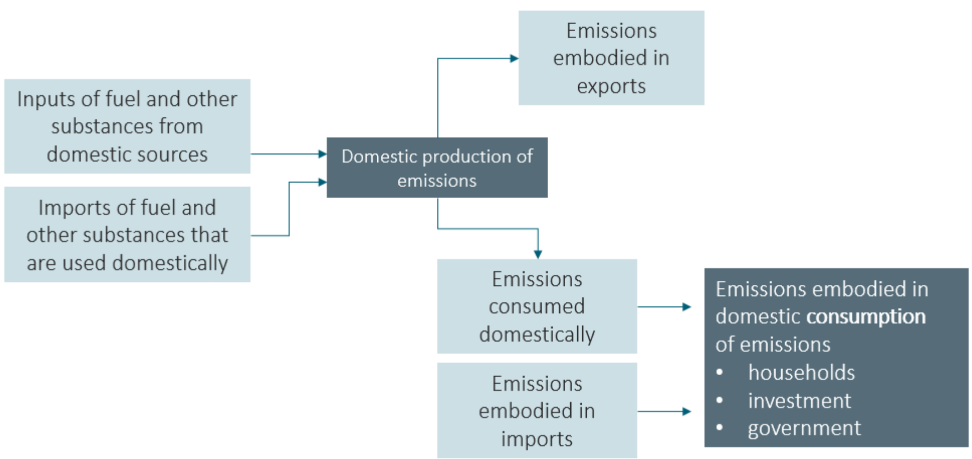
- territorial production approach
- production approach
- consumption approach.

The territorial approach is required for reporting under the United Nations Framework Convention on Climate Change (UNFCCC) framework, and measures all human-caused emissions that occur within a territory. The production approach, based on the SEEA framework, aligns the measurement of emissions with economic production by attributing emissions to the resident economic unit, including activity that takes place overseas, at the point of emission. This allows for the comparisons of industry output and emissions. The consumption approach associates a 'carbon footprint' to the consumption of final goods and services, such as household consumption, government expenditure, and investment in physical assets. This is done by measuring the emissions 'embodied' in a good or service throughout the entire supply chain required to get that good to its final use.

Figure 4 shows how consumption-based emissions can be accounted for after factoring the role of emissions embodied in exports and imports to emissions produced and consumed domestically.

Figure 4

Relationship between domestic production and consumption of emissions approaches



Source: Stats NZ

Environmental taxes

Environmental taxes record the tax payments made by industry and households to government whose tax base is a physical unit (or proxy of a physical unit) of something that has a proven, specific negative impact on the environment, and is identified in the System of National Accounts as a tax.

Examples include fuel taxes, waste levies, and taxes on the extraction of raw materials. These taxes are often interpreted as a societal response to environmental damage. Adjustments to behaviour from taxation in turn affect drivers, pressures, and states.

Other accounts

Other accounts provide relevant information for climate change and the transition to a low-emissions economy (table 2). Asset accounts for timber, water, and fish will enable the impacts of climate change on natural resources to be tracked over time (eg forest fires or changes in water availability). Climate change may affect the extent or condition of ecosystems that provide ecosystem services. Some accounts have yet to be fully developed. This report outlines how existing accounts can be combined with the following accounts to form a richer understanding of the transition to the low emissions economy in an SEEA framework:

- energy physical flows
- timber physical flows
- emissions permits
- subsidies
- ecosystem accounts.

The SEEA approach also allows for close comparisons with drivers of emissions, such as economic and population growth, given the use of similar concepts and principles (such as domestic production). It can also enable analytical indicators such as emissions intensity to be derived and other information such as consumption-based emissions.

Table 2

SEEA accounts relevant for climate change in New Zealand, 2019

		Available	Under development	Not available	Relevance
Drivers	National accounts	x			R
	Energy accounts			x	R
	Land cover / land use accounts[1]	x			R
Pressure	Air emission accounts				R
	Production based	x			R
	Consumption based			x	R
Impacts	National accounts	x			R
	Regional accounts	x			R
	Tourism accounts	x			R
	Agricultural accounts			x	R
	Health accounts			x	R
	Energy asset accounts (subsoil)			x	SR
	Energy asset accounts (renewable)	x			R
	Forest accounts	x			R
	Fisheries accounts				R
	Monetary	x			SR
	Physical		x		R

SEEA accounts relevant for climate change in New Zealand, 2019					
		Available	Under development	Not available	Relevance
Response	Land cover account	x			R
	Land use account			x	R
	Ecosystem accounts		x	x	R
	Mitigation expenditure[2]		x		R
	Adaptation expenditure[2]		x		R
	Environmental goods and services sector			x	R
	Environmental taxes	x			R
	Environmental subsidies		x		R
	Environmental permits		x		R

1. Land cover accounts are available; land use accounts have not yet been developed.

2. Environmental protection expenditure accounts may be useful with further development to show the costs incurred from adaptation and mitigation expenditure. Environmental protection expenditure related to reducing greenhouse gas emissions is included within the recommended classifications for producing environmental expenditure accounts, but currently no distinction is made between expenditure related to air pollution and climate change.

Symbols: SR (some relevance) implies there may be interpretation issues (eg subsoil assets may record part of national wealth but will also contribute to emissions if removed). Likewise, competition may influence monetary values for fisheries as physical stocks decline.

R – relevant

Source: Adapted from Schenau (2009)

Linking information across drivers, pressures, and responses

SEEA enables the integration of various pieces of information that may span the drivers-pressures-state-impact-response (DPSIR) framework by using the concepts, classifications, and definitions consistently across accounts and with the System of National Accounts. Including drivers and responses complements the pressure-state-impact framework used in environmental reporting.

Comparisons are made using these key principles:

- a defined production boundary
- consistent industrial classification and other definitions
- timing of recording.

The greenhouse gas by industry and households account is particularly subject to the production boundary principle. For example, only emissions relating to economic residents of New Zealand are included, but emissions by tourists are not. This approach differs from the 'territorial' approach used in the inventory, which reflects emissions from New Zealand's producing units, rather than 'over' New Zealand. The use of the economic residence principle also aligns with the usually resident population definition, enabling closer comparisons of emissions to population statistics. The timber accounts are also defined by the production boundary, as only timber stocks are valued in monetary terms and only economically viable timber resources are included.

The greenhouse gas by industry and households account and the inventory are both compiled under standard international frameworks but for different purposes. The inventory, the source information for understanding New Zealand's position under the Kyoto Protocol and for achieving national and international targets, is New Zealand's official measure of greenhouse gas emissions. The account provides supporting information for understanding the economic context of greenhouse gas emissions and for showing how they are changing in relation to economic activity.

Using a consistent classification system when compiling information from resident units means that firms are grouped by the similarity of the goods and services they produce. This means agriculture in the greenhouse gas account has the same conceptual coverage as the environmental tax account or other accounts that may be developed in time, such as energy or water use accounts. This differs from how other statistics may be compiled, such as the process-based sectors in the Greenhouse Gas Inventory.

In using the same industrial classification as that underlying economic statistics, changes in greenhouse gases can be compared with economic data for a range of industries. This enables us to assess:

- how emissions have changed in relation to economic growth
- whether structural change in the economy has affected our emissions profile
- where there are opportunities for targeted emissions-reduction policies while maintaining economic growth
- number of persons employed in industries seeking to reduce emissions
- the contribution of industry (as opposed to households) to emissions
- the extent of economic transactions with government (eg taxes and subsidies) related to emissions.

Industries are defined according to the Australian and New Zealand Standard Industrial Classification 2006 in a manner consistent with the national accounts. See Environmental-economic accounts: Sources and methods for industries included in the greenhouse gases by industry and households and environmental taxes account.

The timing of recording principle serves to integrate accounts on a temporal basis and assess relationships between environmental-economic transactions over time (eg by comparing emissions to GDP, employment, or to environmental taxes). As an accounting approach, however, causal links from within the data cannot be drawn but can be integrated in the DPSIR conceptual framework.

From inventory to industry: How the allocation of emissions works

Using the United Nations Framework Convention on Climate Change guidelines, the inventory presents information for carbon dioxide, methane, nitrous oxide, and other pollutants for the agriculture; industrial processes and product use; waste and energy; and land use, land-use change and forestry sectors on a territorial basis. The environmental-economic accounting approach groups inventory data to industrial units and reflects that emissions from an industry may arise due to multiple sources. Both the inventory and environmental-economic accounting approaches record direct emissions from a production perspective.

Estimates of greenhouse gases from the inventory are allocated to industries in one of two ways. In most cases, the emissions in the inventory can be allocated directly (and uniquely) to an industry. For example, emissions from public electricity and heat production are allocated to electricity, gas, water, and waste services. In some cases, notably for road transport, emissions in the inventory are allocated to multiple industries. This is done using additional data sources to give the process-based data an industry dimension. Additional data is used to estimate and adjust for emissions by New Zealanders overseas, or non-residents on the territory (ie resident adjustments).

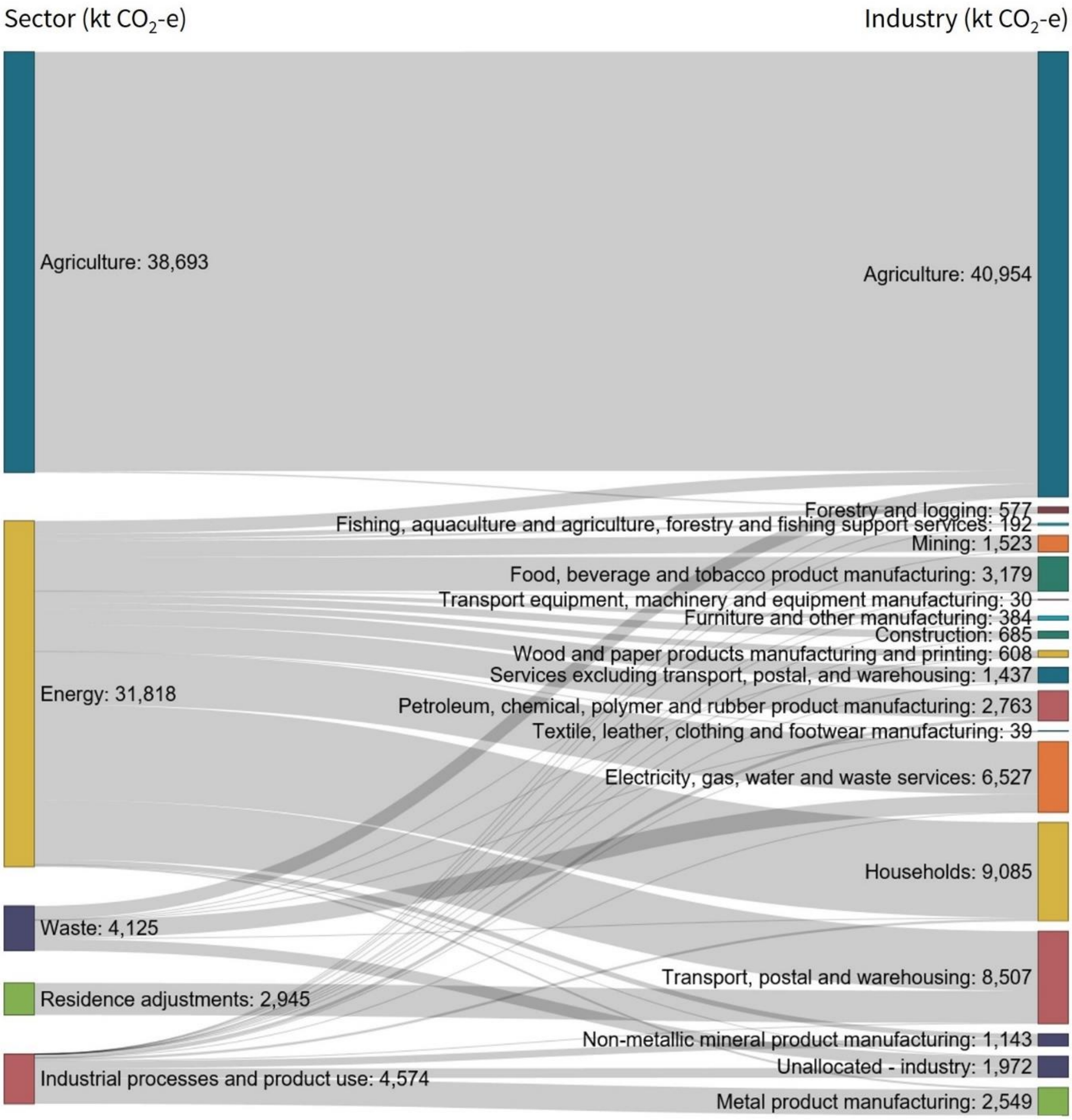
An industry's emissions can arise from multiple processes. For example, emissions from the agriculture industry come from enteric fermentation and fertiliser use, as well as fuel combustion emissions from both stationary and mobile sources and from unmanaged waste disposal sites. While both the inventory and greenhouse gas by industry and households account include categories such as 'agriculture', 'waste', and 'transport', these mean different things in the context of each publication.

Figure 5 shows how sectors from the inventory are allocated to industry. It shows:

- the relative contribution of both sectors and industries to total carbon dioxide equivalent emissions
- that emissions from an industry can arise from several sources
- energy emissions from the inventory are due to activities throughout the economy.

Figure 5

Sankey chart – how the Greenhouse Gas Inventory sectors match industry emissions under the SEEA production based approach, 2017



Note: kt CO_2-e – kilotonnes of carbon dioxide equivalent. Sectors exclude non-residents on domestic territory and other differences in methodology.

Source: Stats NZ

28 June 2019: The version of figure 5 published 27 June had incorrect axis labels (Industry on the left and Greenhouse gas on the right). We've corrected these to 'Sector' on the left and 'Industry' on the right. We've also included a note on the exclusion of non-residents on domestic territory and differences in methodology.

Pressures

This section presents estimates of greenhouse gases (such as carbon dioxide, methane, and nitrous oxide) produced by industries and households. Emissions of greenhouse gases are a pressure on the state of the atmosphere, which affects New Zealand's climate, economy, and society.

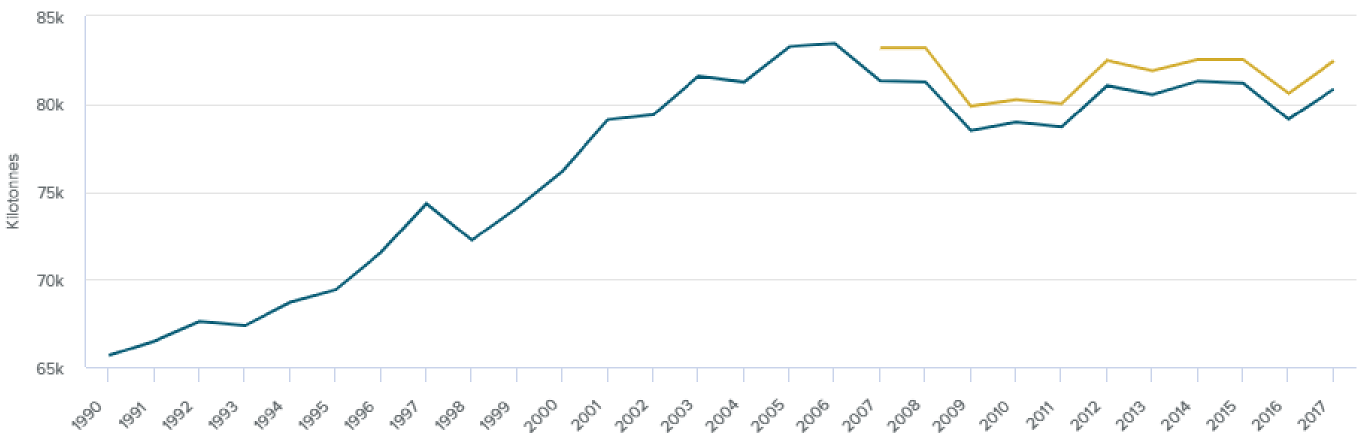
Throughout this report, 'emissions' refers to carbon dioxide equivalents unless otherwise stated. 'Total emissions' refers to gross emissions from industry and households on an SEEA basis.

Total emissions

Carbon dioxide equivalent emissions decreased 0.9 percent (0.1 percent a year) from 2007–17 on an SEEA basis (figure 6). From 2016–17, emissions increased 2.3 percent. Carbon dioxide equivalents include carbon dioxide, methane, nitrous oxide, and fluorinated gases.

Figure 6

CO2-e emissions under the GHG inventory and SEEA approaches, 1990–17



Data not available is shown as NaN in the table. CO2-e = carbon dioxide equivalent

Stats NZ

Emissions as measured under the SEEA were 2.0 percent (1,604 kilotonnes) higher than those under the inventory in 2017. This is because emissions from New Zealand's activities overseas exceeded those by non-residents on the domestic territory (residence adjustments). Table 3 shows the contribution of residency adjustments to the greenhouse gas by industry and households accounts.

Table 3

Sources of differences between the Greenhouse Gas Inventory and SEEA greenhouse gases by industry and households account		
	2007	**2017**
GHG inventory total – gross emissions	81,322	80,851
Non-residents operating on domestic territory	-961	-1,153
Residents operating overseas	3,076	2,945
Difference	-238	-187
Greenhouse gas by industry and households account total	83,198	82,455
Source: Stats NZ		

Other differences are due to the inclusion of Tokelau in the inventory, which is excluded from SEEA, and differences in the methods for agriculture emissions.

Comparing gases using global warming potentials

Carbon dioxide is the greenhouse gas (GHG) most commonly associated with climate change. GHGs accumulate in the atmosphere, absorbing and emitting outgoing thermal radiation and re-emitting some of it back towards Earth. This traps heat in the atmosphere, causing what is known as the 'greenhouse effect'.

There are several other important greenhouse gases in the context of climate change. However, their impacts on warming vary because of their differing lifetimes in the atmosphere and their capacity to absorb radiation. These factors lead to differences in the amount of heat trapped by each gas. We can examine these differences to estimate global warming potentials, which measure the amount of heat trapped by each GHG relative to carbon dioxide.

Methane, for example, has a global warming potential 25 times that of carbon dioxide over a 100-year period, but its expected lifetime is about 12 years. Nitrous oxide has a global warming potential 298 times carbon dioxide, and a lifetime of 114 years. The atmospheric lifetime of carbon dioxide usually ranges from 5 to 200 years but some can remain there for thousands of years. Fluorinated gases generally have long lifetimes and high global warming potentials. These global warming potentials are consistent with those used in the Greenhouse Gas Inventory and as reported in the Intergovernmental Panel on Climate Change's Fourth Assessment Report.

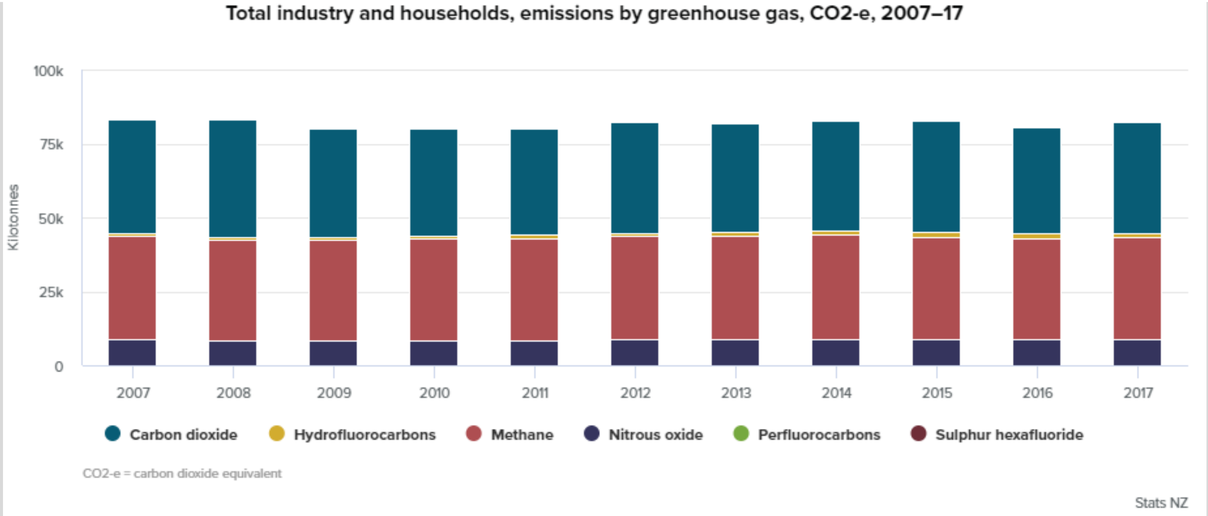
Global warming potentials enable comparison of the warming effects between different gases. They can be used to calculate emissions in terms of carbon dioxide equivalents, which express the global warming effect of a gas relative to the global warming effect of carbon dioxide.

New Zealand's greenhouse gas emissions, based on the SEEA, mainly come from carbon dioxide (45.9 percent of total emissions), methane (41.4 percent), and nitrous oxide (10.8 percent). Fluorinated gases account for just 1.9 percent of total emissions. These proportions have remained relatively constant since 2007 (figure 7), although the contributions of industries and sources that give rise to these emissions have changed over time.

Carbon dioxide emissions are mainly due to the combustion of fossil fuels, while methane and nitrous oxide are due to agricultural activity. New Zealand's share of global GHG emissions is just

0.17 percent of total global emissions, but our gross emissions per person are among the highest (Stats NZ & MfE, 2017)

Figure 7



Drivers of total emissions: population and the economy

Economic and population growth are drivers of emissions, while reductions in emissions intensity (or significance of emissions to generate output) can offset these drivers. Figure 8 decomposes the change in emissions into changes in:

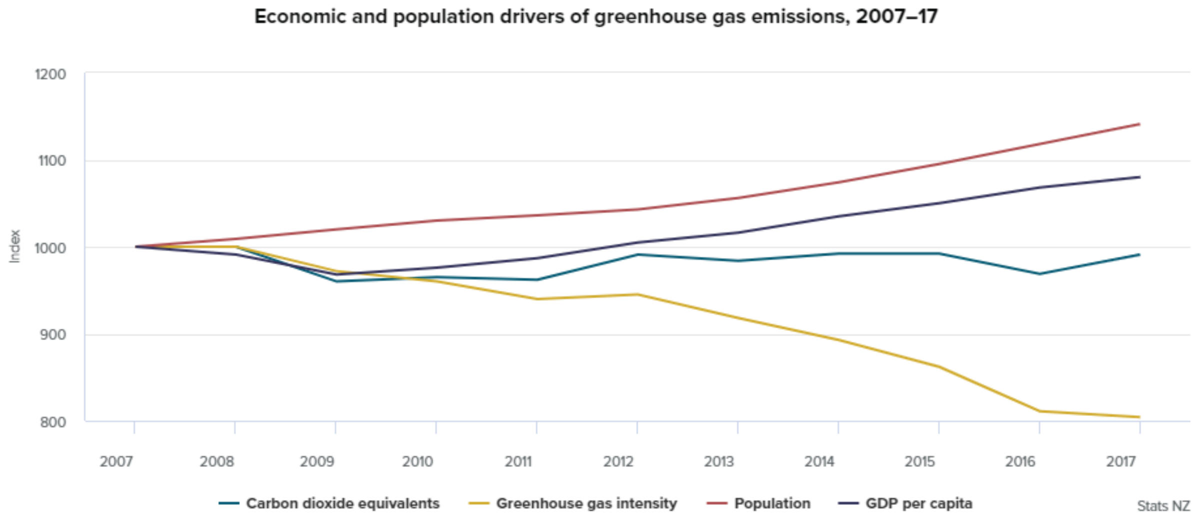
- emissions intensity – measured as emissions per unit of GDP
- GDP per capita, which is often taken to refer to economic living standards
- population – measured as the usually resident population.

Population growth contributed to increased emissions in all years from 2007. GDP per capita declined in 2008 and 2009, contributing to decreases in emissions in these years. Emissions intensity decreased in all years except 2012, and offset the upward contributions from living standards and population growth over the period.

Emissions intensity, in terms of levels and growth, can reflect several factors including:

- carbon content of imports and exports and reliance on overseas trade for economic production
- structure of the economy and shifts towards different broad industry groups over time (eg from goods-producing to service industries) which may be less emissions-intensive
- technological change which allows for economic activity to be maintained while decreasing emissions
- energy intensity (the amount of energy consumed per unit of GDP)
- fuel mix (the amount the energy used to generate carbon dioxide).

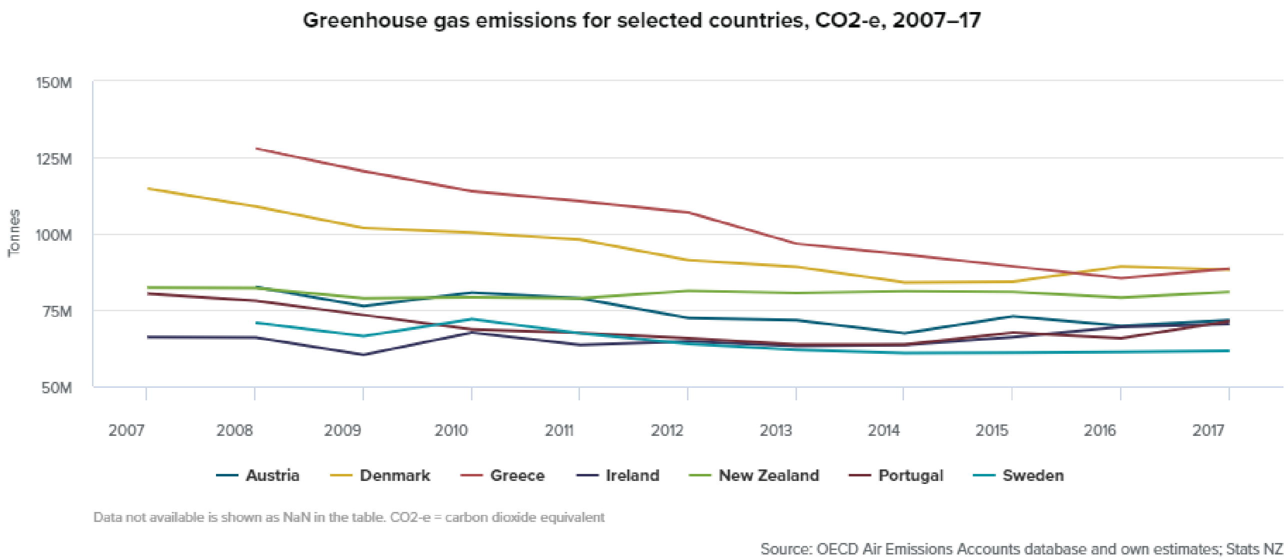
Figure 8



International comparisons

Comparing emissions levels across countries shows the scope for which an individual country can influence global concentrations. New Zealand's contribution to the global carbon budget is small, accounting for just 0.17 percent of global emissions (Stats NZ & MfE, 2017). New Zealand's emissions were similar to those for Greece, Portugal, Denmark, Austria, Sweden, and Ireland in 2017. Figure 9 shows how emissions in these countries have changed since 2007.

Figure 9



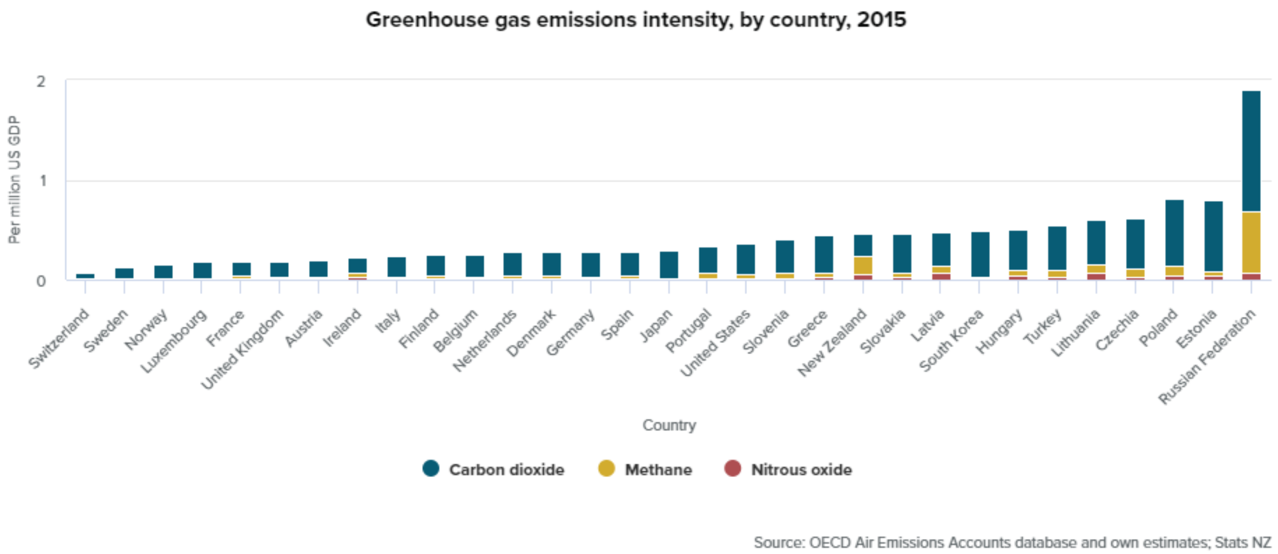
Comparing emissions levels, however, does not account for the intensity in effort to produce greenhouse gases. This is obtained by assessing emissions on a per capita or per unit of output basis and thus accounting for different sizes of populations and economies. Comparing emissions to GDP provides information on the de-carbonisation of the economy.

New Zealand's emissions intensity (total emissions per million dollars of GDP expressed in US dollars) was 11th highest of 31 countries in 2015 for which emissions intensities could be compiled for. The countries used in this comparison are OECD countries, plus others for which the OECD has estimated emissions on an SEEA basis, and where GDP data was available. Countries where emissions data by gas was not available were excluded (ie Canada and Australia). However, in 2015, total emissions intensity for Canada is higher than New Zealand's while Australia's is lower.

Economies of similar size to New Zealand (in terms of current price GDP in USD) include Greece, Czechia, and Portugal. Greece and Portugal also have emission intensities that are comparable to New Zealand's. However, emissions intensities are often unrelated to the size of the economy. The emissions intensity for Slovakia is similar to that for New Zealand, even though its economy is half the size.

Differences in industry composition (which may also relate to gas profile) affect emissions intensities across countries. (World Resources Institute, 2005). Carbon dioxide intensity, for example, is much lower for New Zealand given the significance of methane emissions. New Zealand's carbon dioxide intensity was 21st highest of 31 countries in 2015 (figure 10). New Zealand, next to Russia, had the largest difference between its total GHG and carbon dioxide intensities. While methane and nitrous oxide are also emitted by other countries, the extent of these is much more significant for New Zealand in terms of its gas profile due to the significant role of agriculture.

Figure 10



Total emissions for five countries (Turkey, South Korea, Russian Federation, Luxembourg, and Ireland) increased over 2008–15, which is the longest period for which data are available for 38 countries. New Zealand's decrease of 0.8 percent over the period was the second smallest decrease, next to Japan.

The Emissions by country dashboard shows how emissions from New Zealand's industries and households compare with those from other countries.

This approach to measuring emissions intensity used here aligns the production of emissions to the economic value added from production obtained from those emissions. Gases used in these comparisons include: carbon dioxide, methane, and nitrous oxide. Other studies use purchasing power parities to standardise the relative purchasing power of incomes across countries, but relates to the expenditure method of GDP, rather than production. Emissions intensities are compared as a snapshot to remove the effect of inflationary pressures. Emissions intensities can also vary on the year selected given movements in exchange rates.

Consumption-based emissions estimates

The role of consumption-based emissions accounting is particularly important when assessing emissions across countries and trade linkages, and therefore the pressure of trade on emissions. Differences between a nation's production and consumption patterns due to trade can portray radically different trends over time as the structure of the economy and trade changes (eg see Barrett et al, 2013 for UK estimates). Consumption estimates therefore provide a complementary approach to production estimates to produce a more nuanced understanding of a nation's emissions by showing how a nation's supply and demand interact with the global economy. Figure 4, shown earlier, shows that the difference between the two measures represents the emissions that are embodied in trade.

Emissions embodied in trade are continuing to increase on a global basis (OECD, 2019). Understanding that both production and consumption affect emissions is becoming critical – what is ultimately important is global GHG emissions.

No official consumption-based estimates exist for New Zealand, but the potential insights from this approach are clear given our trade patterns. Of our top 20 export commodities by value, 13 depend on natural resources or activity in primary industries, such as milk products, meat, fruit, wine, fish, wood, petrol, wool, and minerals. These accounted for 70 percent of export value in 2018.

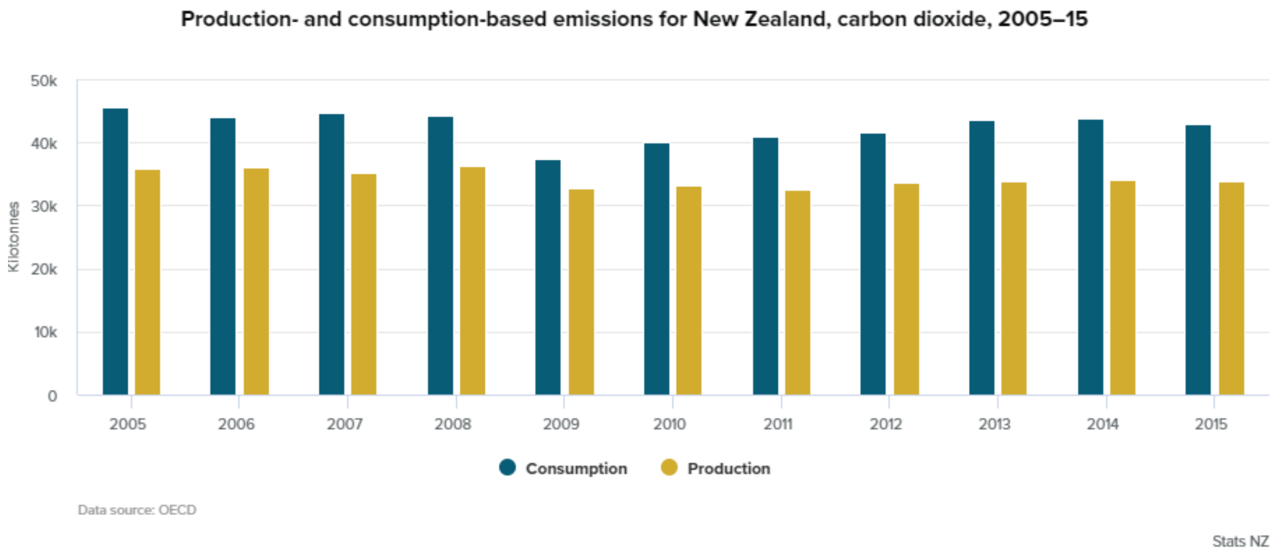
Goods exports (excluding services) accounted for 19.0 percent of GDP in current prices in the year ended March 2017. However, emissions directly produced by these industries and associated manufacturing account for over half of New Zealand's emissions. Much of these are methane, suggesting a significant proportion of domestic emissions are 'exported'. On the other hand, imported goods generally consist of manufactured goods. These include goods that contribute to emissions (eg cars) and technologies that may reduce emissions (eg electric vehicles). Consumption-based emissions accounting can assist in identifying the role of trade intensity, the relative influence of demand and supply on managing emissions, the dependency of New Zealand on other countries for reducing its emissions, and the final consumer of emissions. This highlights the broader international trade context in which emissions are produced.

OECD (2019) estimates consumption-based emissions for carbon dioxide using an inter-country input-output (ICIO) model combined with industry economic statistics and International Energy Agency statistics on carbon dioxide emissions from fuel combustion. Consumption (demand)-based carbon dioxide emissions are defined as emissions from final demand (household consumption, government, and industry investment) for embodied carbon that has been emitted anywhere in the world along global production chains.

Comparisons of carbon dioxide consumption compared to production shows the environmental impacts of global production systems. Figure 11 shows the OECD's estimates for consumption of carbon dioxide emissions embodied in domestic final demand and carbon dioxide emissions from production (based on the territory principle) for New Zealand. When considering carbon dioxide only, excluding methane, nitrous oxide, and other gases, New Zealand is a net importer of carbon as its consumption of carbon dioxide exceeds its production. Not all OECD countries are net importers of carbon; for example, Canada, Korea, and the Netherlands were net exporters in 2015.

Among OECD and G20 countries, the average of the three countries with the highest per capita demand-based emissions (Australia, Saudi Arabia, and United States, 18.3 tonnes of carbon dioxide) is nearly 10 times higher than that for the three countries with the lowest per capita emissions (Brazil, Indonesia, and India, 1.9 tonnes of carbon dioxide). New Zealand, at 9.3 tonnes carbon dioxide per capita in 2015, was lower than the OECD average of 10.8 but higher than the APEC (Asia-Pacific Economic Cooperation) average of 7.0.

Figure 11



Industry emissions

Emissions by industry accounted for 89 percent of total emissions in 2017, with households accounting for 11 percent. Total industry emissions decreased at an average of 0.3 percent a year from 2007–17. Total emissions were down over this period, but the decrease in industry emissions was largely offset by households (up 1.8 percent a year).

From 2007–17, total industry emissions decreased 2.9 percent (or 2,217 kilotonnes), with decreases coming from:

- electricity and gas supply – down 41.7 percent (3,359 kilotonnes)
- sheep, beef cattle, and grain farming – down 11.7 percent (2,969 kilotonnes)
- poultry, deer, and other livestock farming – down 43.6 percent (727 kilotonnes)
- mining – down 24.6 percent (497 kilotonnes)
- water, sewerage, drainage, and waste services – down 20.9 percent (485 kilotonnes)
- non-metallic mineral product manufacturing – down 28.5 percent (456 kilotonnes)
- rail, water, air, and other transport - down 8.8 percent (437 kilotonnes)

However, emissions increased for:

- dairy cattle farming– up 27.7 percent (3,636 kilotonnes)
- petroleum, chemical, polymer, and rubber product manufacturing – up 63.1 percent (1,069 kilotonnes)
- food, beverage, and tobacco product manufacturing – up 44.8 percent (984 kilotonnes)
- road transport – up 16.5 percent (548 kilotonnes)
- services excluding transport, postal, and warehousing – up 36.0 percent (460 kilotonnes)
- construction – up 65.9 percent (272 kilotonnes)

- forestry and logging – up 54.1 percent (203 kilotonnes).

Table 4 summarises the contributions of industries to emissions in 2017, the change in emissions from 2007–17, and average growth rates for key industries and gases. Further industry details are available in the downloadable Excel tables.

Table 4

Contribution, change, and annual growth of emissions by industry, 2007-17

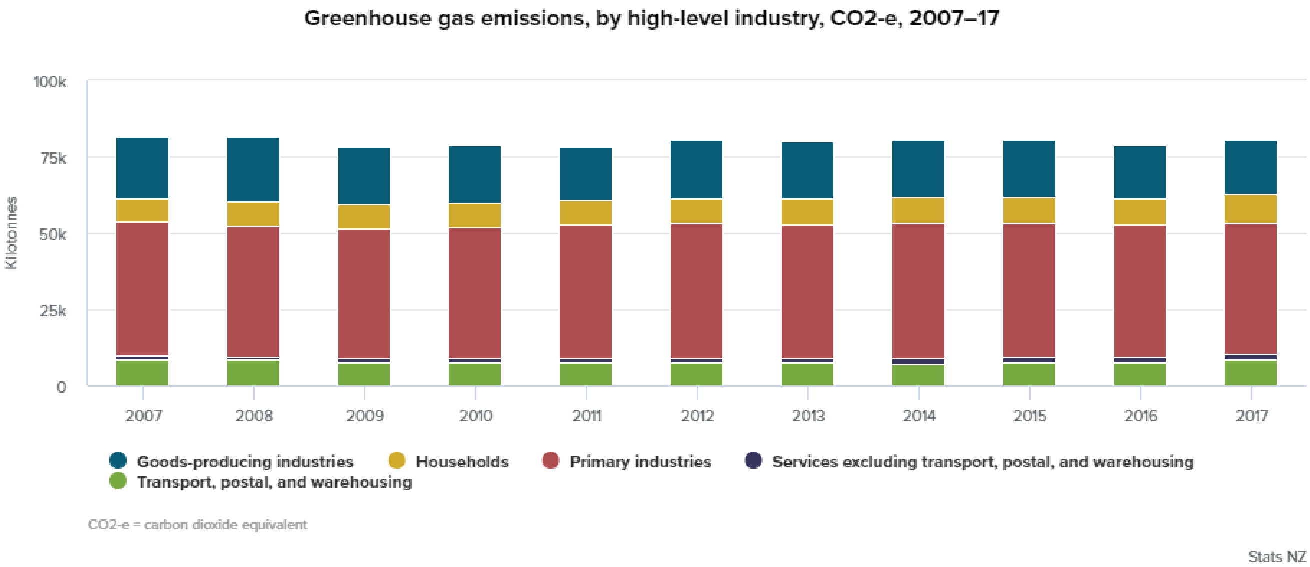
Industry (ANZSIC06) and households	2017	2007-17			
			Key gases		
	Contribution to total CO_2-e	Change in CO_2-e	CO_2-e	CO_2	Methane
	% of total	Kilotonnes	Average annual % change		
Primary industries	52.4	-771	-0.2	-1.5	-0.2
Agriculture, forestry, and fishing	50.6	-274	-0.1	-1.1	-0.1
Agriculture	49.7	-239	-0.1	-1.5	-0.1
Forestry and logging	0.7	203	4.4	9.1	-3.3
Fishing, aquaculture and agriculture, forestry and fishing support services	0.2	-238	-7.8	-7.8	-6.2
Mining	1.8	-497	-2.8	-2.5	-3.6
Goods-producing industries	21.7	-2,380	-1.2	-1.2	-1.7
Manufacturing	13.0	1,192	1.2	1.1	4.4
Electricity, gas, water, and waste services	7.9	-3,844	-4.5	-5.4	-2.3
Construction	0.8	272	5.2	5.2	3.3
Service industries	12.4	506	0.5	0.4	-5.5
Transport, postal, and warehousing	10.3	46	0.1	0.1	-8.7
Services excluding transport, postal, and warehousing	2.1	460	3.1	2.9	2.5
Total all industries	89.0	-2,217	-0.3	-0.8	-0.2
Households	11.0	1,473	1.8	1.8	0.1
Total	100.0	-744	-0.1	-0.2	-0.2

Note: $CO_{2\text{-}e}$ – carbon dioxide equivalent

Source: Stats NZ

Figure 12 shows the relative contributions of broad industry groups and households to total carbon dioxide equivalent emissions from 2007–17. Primary industry contributions remained relatively constant, while goods-producing industries' contributions decreased from 24 percent to 22 percent. Household's contribution increased from 9 percent to 11 percent.

Figure 12



From 2016–17, carbon dioxide equivalent emissions increased 2.3 percent, completely offsetting the decrease of 2.3 percent from 2015–16. Industries that contributed to the 2.3 percent increase in emissions from 2016–17 were:

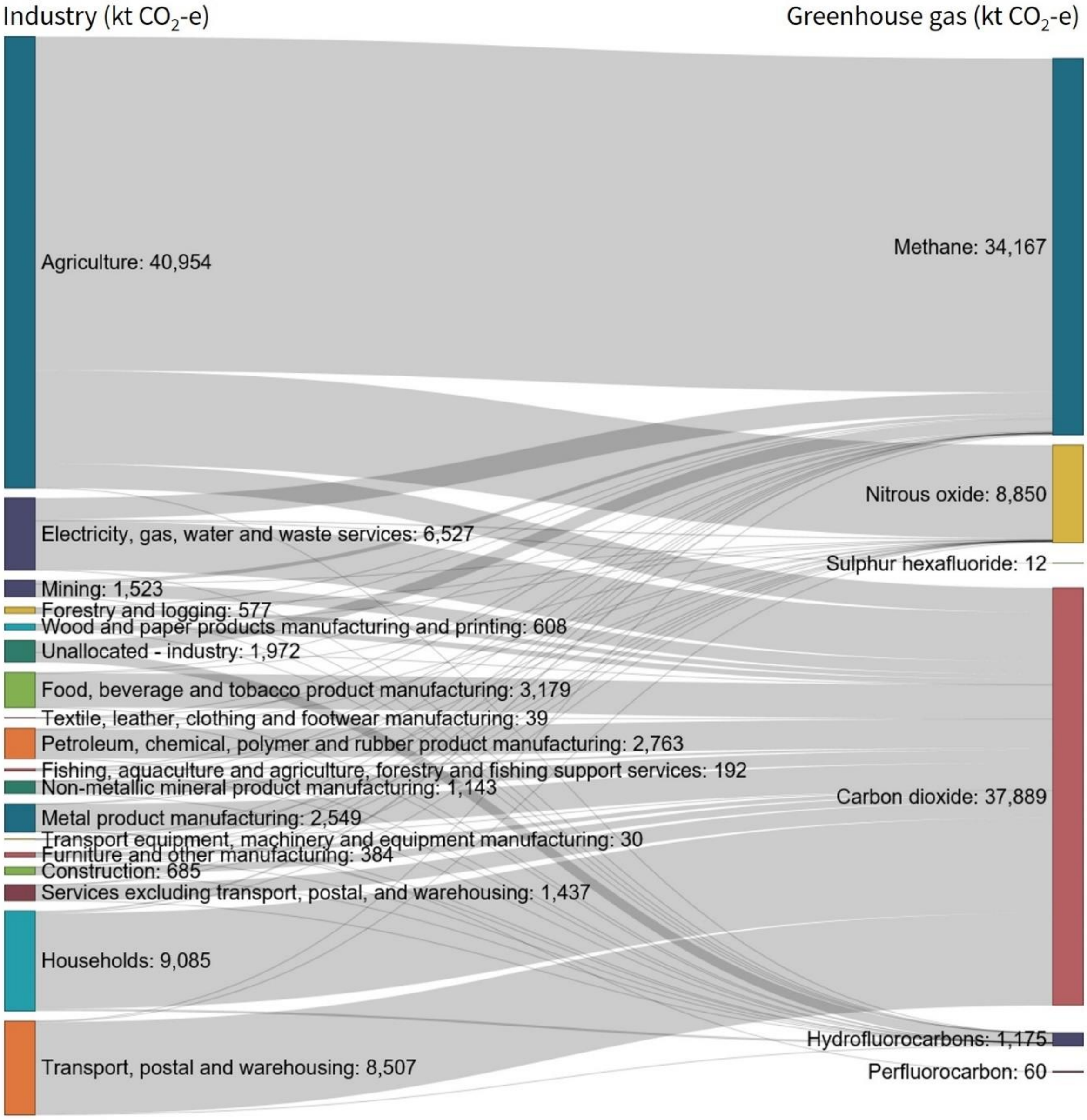
- sheep, beef cattle, and grain farming – up 360 kilotonnes
- food, beverage, and tobacco product manufacturing – up 403 kilotonnes
- electricity and gas supply – up 520 kilotonnes
- road transport – up 647 kilotonnes.

Emissions in 2017 decreased in dairy cattle farming (down 446 kilotonnes) and petroleum, chemical, polymer, and rubber product manufacturing (down 377 kilotonnes).

Figure 13 shows the gas profile by industry in 2017. Most methane emissions were from agriculture, with additional contributions from electricity, gas, water, and waste services. Agriculture was also the main contributor to nitrous oxide emissions. All other industries, particularly electricity, gas, water, and waste services; transport, postal, and warehousing; and households, contributed to carbon dioxide emissions (which mainly follow from energy emissions).

Figure 13

Sankey chart – how CO_2-e emissions by industry correspond to emissions by gas type, 2017



Note: kt CO_2-e – kilotonnes of carbon dioxide equivalent

Source: Stats NZ

Environmental-economic accounting perspective on greenhouse gases by industry and voluntary greenhouse reporting

In focusing on the range of emissions produced by an industry, the environmental-economic accounting approach may be useful in the context of voluntary reporting of greenhouse gases by companies. In some circumstances, it may be possible for industry-level data to serve as benchmarks for companies to see how their emissions are tracking relative to that for an industry.

Voluntary guidance on greenhouse gas reporting (the GHG Protocol) for companies outlines three scopes:

- scope 1 records direct emissions from sources owned or controlled by the company from stationary fuel combustion, transport (including taxis and rental cars), and refrigerants.
- scope 2 refers to indirect emissions from purchased electricity
- scope 3 includes other indirect emissions such as transmission and distribution line losses for purchased electricity and distributed natural gas, air travel, and waste to landfill.

Scopes 1 and 2 are required to be produced under the GHG Protocol while scope 3 is optional.

In broad terms, the SEEA framework aligns to scope 1 (direct emissions from the operator) except for taxis, which are allocated to the road transport industry. Scopes 2 and 3 align more closely with the consumption of emissions rather than production.

Under SEEA, scope 2 emissions are allocated to the electricity and gas supply industry, while scope 3 emissions would be allocated across these industries: electricity and gas supply; water, sewerage, drainage, and waste services; and rail, water, air, and other transport.

Measuring emissions: A guide for organisations (MfE) provides guidance on how organisations can voluntarily report their greenhouse gas emissions.

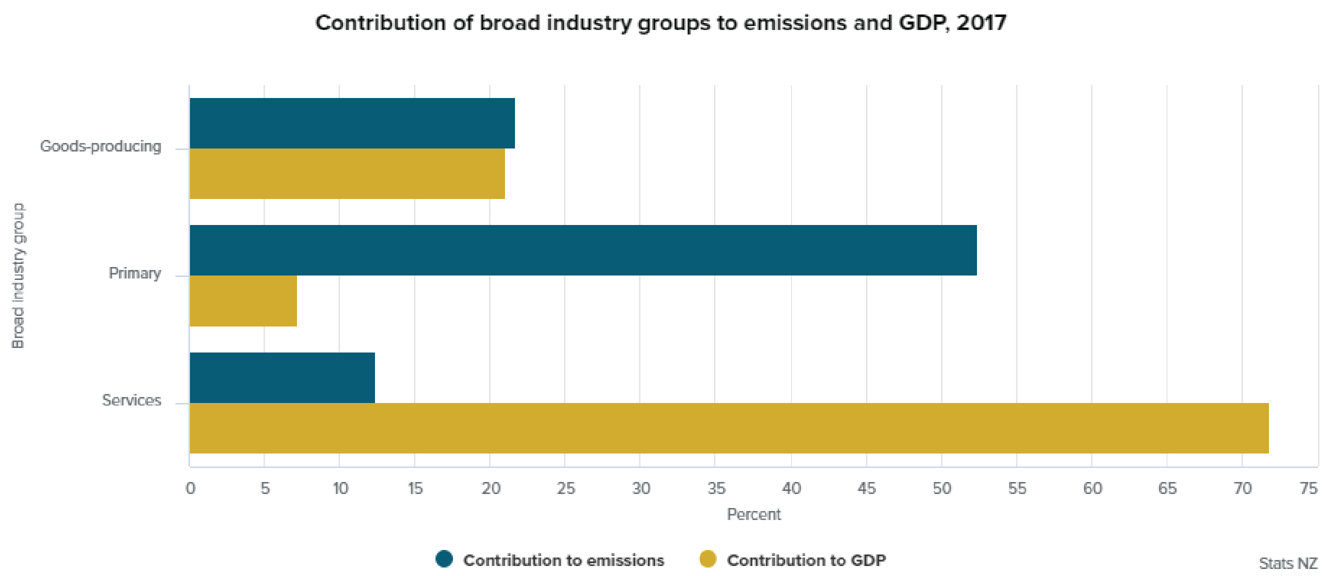
Firms seeking to use emissions estimates from the SEEA as an indication of relative performance can compare their scope 1 emissions with those from the same industry.

Emissions and economic activity by industry

In aligning emissions to economic data, we can get further insight into the industry drivers of emissions or the trade-offs between emissions and economic growth.

In 2017, about 300 tonnes of greenhouse gases were emitted by industry and households for each million dollars of GDP (in current prices). Total industry emissions intensity (emissions in relation to economic output) is strongly influenced by service industries, which account for 65.6 percent of GDP but only 12.4 percent of emissions (figure 14). Primary industries, however, account for 52.4 percent of emissions but only 6.6 percent of GDP (in current prices). Goods-producing industries, on average, contribute as much to emissions as they do to GDP.

Figure 14

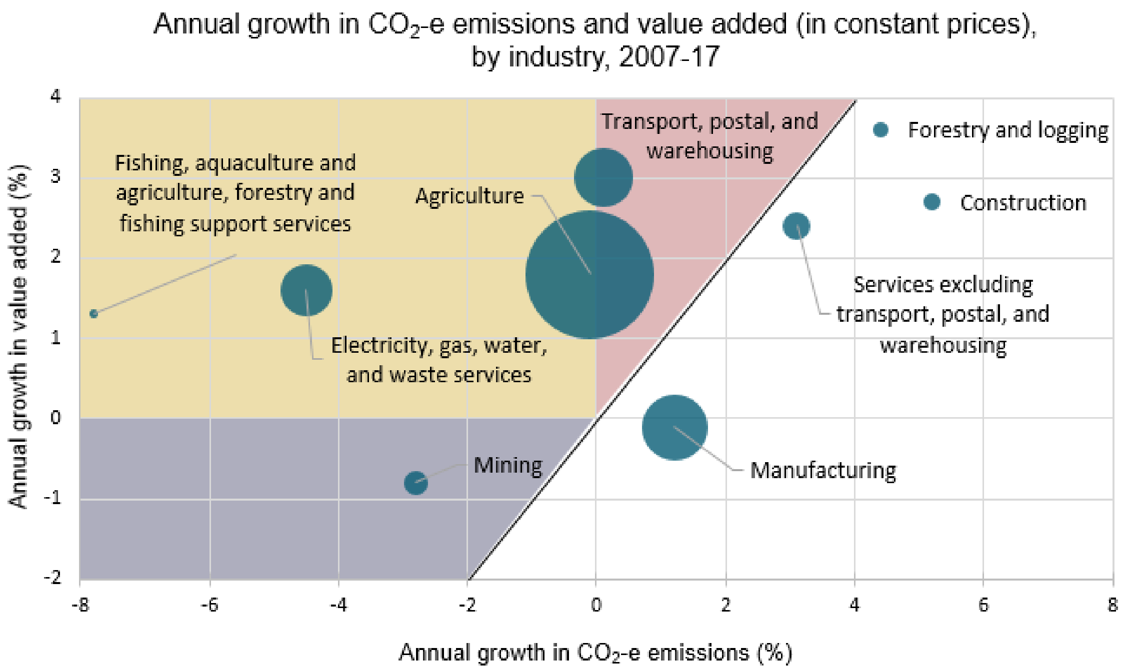


Activity in the primary industries generates further activity in other parts of the economy, such as manufacturing. A value chain approach would capture these interactions and give a more complete perspective on emissions intensities. However, these are captured at the national level where all inter-industry transactions are accounted for.

Comparing an industry's direct emissions to its direct contribution to GDP (expressed in real terms) (also referred to as 'value added') shows whether changes in emissions are related to changes in economic activity.

Figure 15 shows the annual changes in value added (in constant prices) and emissions by industry. The size of a bubble reflects the industry's proportion of total economy emissions in 2017. Industries whose centre is to the left of the 45-degree line saw growth in their value added increase faster than emissions in either relative (red or blue area) or absolute (yellow area) terms. Industries to the right saw their emissions increase at a faster rate, in either absolute or relative terms, value added (ie greenhouse gas intensity increased).

Figure 15



Note: The size of the bubble reflects an industry's contribution to emissions in 2017. The black line is a 45-degree line. Carbon dioxide equivalent emissions increased at a faster rate than value added for industries to the right of the line, and at a slower rate for those to the left. Industries in the top-left quadrant are those that had absolute decoupling (value added increased while carbon dioxide equivalent emissions decreased). Industries that had their value added and emissions grow in the same direction, but value added grew relatively faster, showed relative decoupling.

From 2007–17, electricity, gas, water, and waste services, and fishing, aquaculture and agriculture, forestry and fishing support services recorded a decrease in emissions while their value added increased, thus showing absolute decoupling.

Mining recorded a decrease in emissions but also a decrease in its contribution to GDP. Agriculture emissions decreased 0.1 percent a year (although no significant trend could be observed) while value added grew 1.8 percent a year. The transport, postal, and warehousing industry showed relative decoupling, that is emissions and value added grew, but value added grew at a faster rate. Emissions increased at a faster rate than value added for:

- forestry and logging
- construction
- services excluding transport, postal, and warehousing
- manufacturing.

Within manufacturing, some industries showed relative decoupling while others showed emissions increasing faster than value added. See manufacturing emissions for more detail.

The growth in emissions from the forestry industry reflects only energy, road transport, and some livestock emissions. The greenhouse gas by industry and households accounts exclude emissions and removals from the land use and forestry sector including tree planting, harvesting, and land conversion (Eurostat, 2015). For more information on the role of forestry see Carbon sequestration and the role of forestry.

Agriculture emissions

Emissions from the agriculture industry accounted for 49.7 percent of New Zealand's total emissions and 88.7 percent of methane emissions in 2017. This industry also accounted for 94.9 percent of nitrous oxide emissions. Most of these emissions came from livestock, followed by fertiliser applications, energy, and then waste. Agriculture's contribution to total emissions was greater than that in the inventory because SEEA includes direct energy and waste emissions from agricultural producers. Industries within agriculture include:

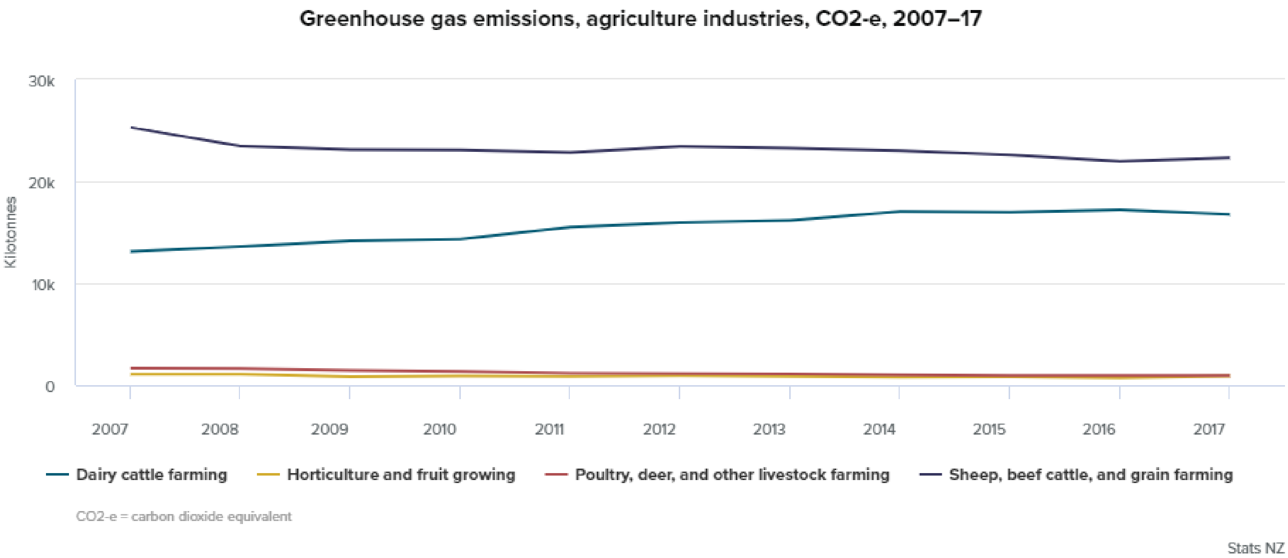
- horticulture and fruit growing
- sheep, beef cattle, and grain farming
- dairy cattle farming
- poultry, deer, and other livestock farming.

Sheep, beef cattle, and grain farming accounted for over half of the agriculture industry's emissions and 27.1 percent of total emissions in 2017, making it the largest emitting industry. Dairy cattle farming accounted for 20.3 percent of total emissions, similar to emissions from manufacturing, and electricity and gas supply combined.

Carbon dioxide equivalent emissions in agricultural industries decreased 0.1 percent a year on average from 2007–17. Emissions of methane decreased 0.1 percent a year while those of carbon dioxide decreased 1.5 percent a year.

Within the agricultural sub-industries, emissions (carbon dioxide equivalents, carbon dioxide, and methane) decreased for all industries except dairy cattle farming. Methane and carbon dioxide equivalent emissions increased 2.4 percent and 2.5 percent a year, respectively, for dairy cattle farming over 2007–17. Sheep, beef cattle, and grain farming had the highest level of emissions over the period, but dairy cattle farming emissions began to converge. (figure 16) Horticulture, and poultry, deer, and other livestock farming each accounted for just 1.1 percent of total emissions.

Figure 16

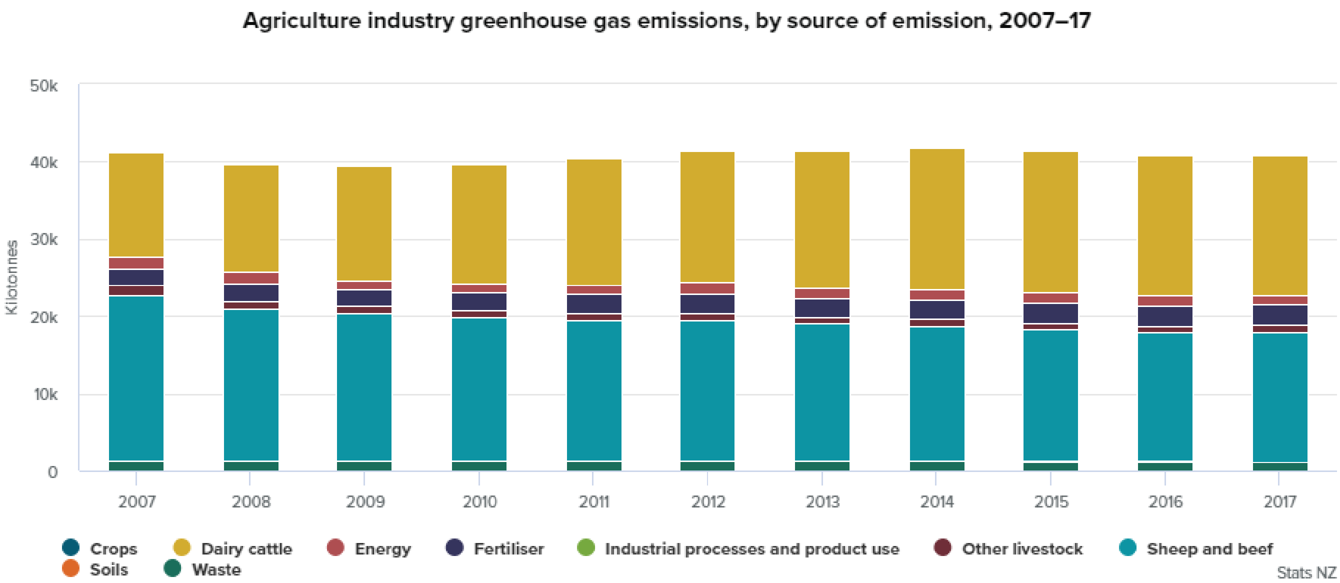


Increased dairy cattle farming emissions were driven by emissions from livestock (enteric fermentation and manure management). In 2017, emissions from dairy cattle accounted for 81.9 percent of total dairy cattle farming emissions, with the remaining 18.1 percent coming from other sources such as cropping, fertiliser, other livestock, energy, and waste.

Emissions from sheep, beef cattle, and grain farming declined 1.2 percent a year from 2007–17. Declining sheep and beef cattle numbers contributed to this, but increased co-production involving dairy cattle partially offset these effects.

Figure 17 shows the contribution of various sources to agriculture industry emissions. Emissions from dairy cattle (includes enteric fermentation and manure management) and fertiliser were the only source categories to increase from 2007–17, up 35.3 percent and 20.3 percent, respectively. Emissions from sheep, beef, and dairy cattle accounted for 85.4 percent of total agriculture emissions in 2017.

Figure 17



Emissions from final agricultural products, as opposed to industry, include products across the wider value chain. While a full value chain approach has not yet been developed, an example of the wider emissions relating to agriculture can be shown through associated food product manufacturing emissions.

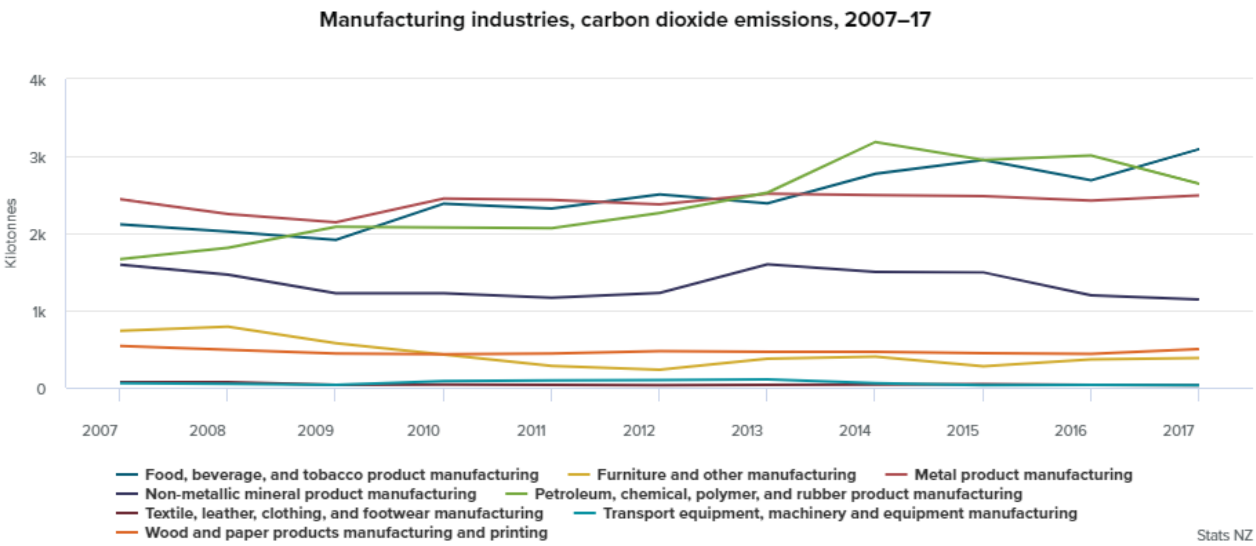
The food, beverage, and tobacco manufacturing industry, which accounted for 3.3 percent of GDP in 2017, is heavily dependent on agriculture outputs as inputs into their production. The food, beverage, and tobacco product manufacturing accounted for a further 3.9 percent of total emissions – emissions increased 3.8 percent a year from 2007–17 while value added increased 0.3 percent a year. Understanding the wider impacts is also relevant for employment as agriculture and food, beverage, and tobacco product manufacturing employed 200,892 people in 2017.

Manufacturing emissions

Manufacturing was the biggest emitter of carbon dioxide in 2017 (accounting for 27.3 percent). Households were the next biggest emitter (22.9 percent), followed by transport, postal, and warehousing (22.1 percent). Carbon dioxide can stay in the atmosphere for thousands over years (its lifetime) compared with methane and nitrous oxide which are both much shorter lived. Carbon dioxide emissions from manufacturing increased 1.1 percent a year from 2007–17.

Figure 18 shows the food, beverage, and tobacco product manufacturing had the highest carbon dioxide emissions of all manufacturing industries in 2017. This was followed by petroleum, chemical, polymer, and rubber product manufacturing; and metal product manufacturing. Carbon dioxide accounted for 96 percent of total manufacturing emissions in 2017.

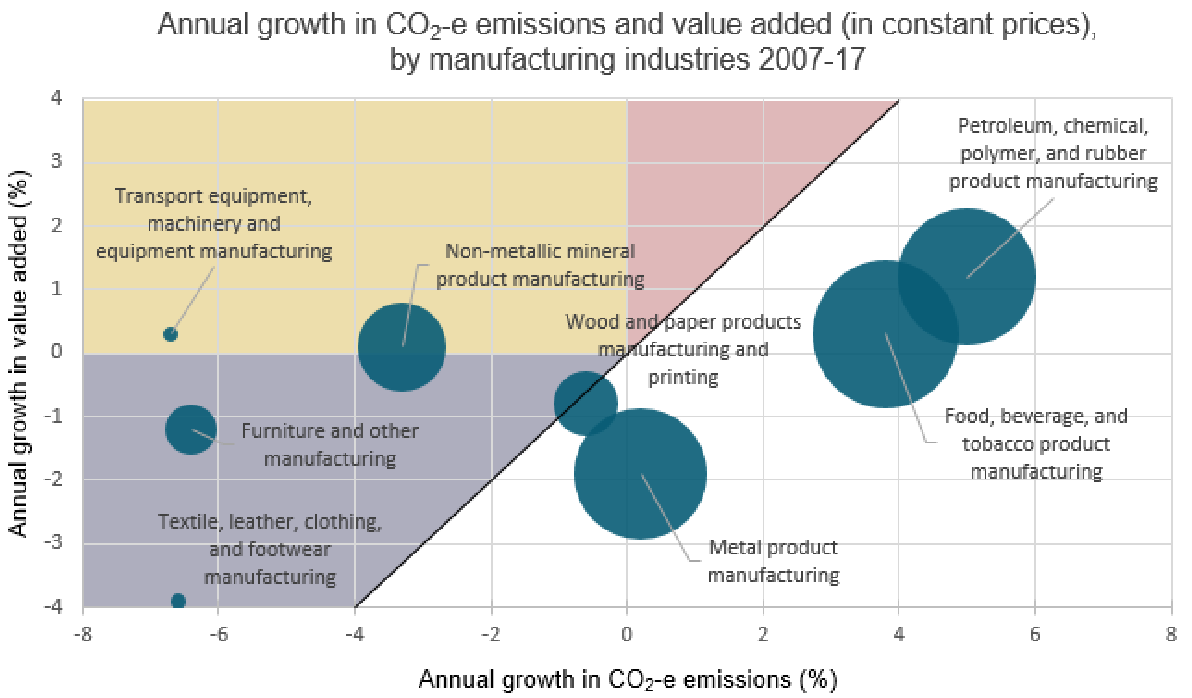
Figure 18



The petroleum, chemical, polymer, and rubber product manufacturing industry showed the highest growth from 2007–17 at 5.0 percent a year. Driving this growth was emissions from energy use for chemicals manufacturing, which increased threefold, while emissions from chemical industry and petroleum refining were stable. Value added for petroleum, chemical, polymer, and rubber product manufacturing increased 1.2 percent a year over 2007–16.

Figure 19 shows how value added and emissions have changed in the manufacturing industries from 2007–17.

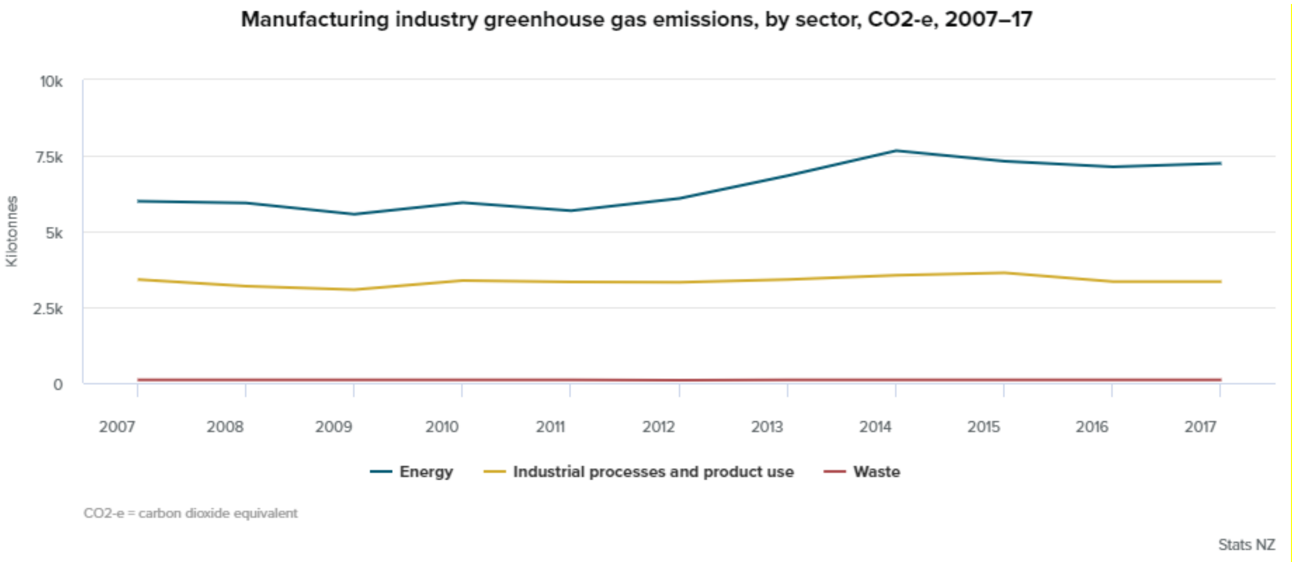
Figure 19



In the context of the transition to a low-emissions economy, the number of people employed by industry may be of interest. Industries with increasing emissions intensities, those to the right of the dark line (figure 19), employed 192,096 people in 2017. Total people employed in manufacturing was 265,761 in 2017. In contrast, services (excluding transport, postal, and warehousing) accounted for most of the people employed (1,745,301 out of 2,468,394), but only 2.1 percent of emissions.

Manufacturing emissions come from the Greenhouse Gas Inventory's energy, industrial processes and product use, and waste sectors (figure 20). Energy has been a main contributor since 2007, and accounted 67.8 percent of manufacturing emissions in 2017. Industrial processes and product use accounted for 31.2 percent of emissions for manufacturing.

Figure 20



Of the manufacturing sub-industries, petroleum, chemical, polymer, and rubber product manufacturing; non-metallic mineral product manufacturing; and metal product manufacturing, have emissions from both energy and industrial processes and product use sectors.

Industrial processes and product use sectors are most significant for metal product manufacturing (92.8 percent of emissions) followed by non-metallic mineral product manufacturing (58.6 percent of emissions), and petroleum, chemical, polymer, and rubber product manufacturing (11.0 percent). Manufacturing industries accounted for 67.2 percent of total industrial process and product use emissions in 2017.

Understanding manufacturing emissions through energy accounts

Given the significance of manufacturing for New Zealand's carbon dioxide emissions, energy accounts would enhance understanding of the role of energy use for manufacturing, as well as the rest of the economy. The SEEA central framework outlines how to record the physical supply and use of energy that can enhance the understanding of greenhouse gases by industry.

Energy balance statistics, such as those produced by MBIE, would form the main input into SEEA energy accounts, but to align with SEEA definitions these data would be adjusted to account for imports and exports and alignment to ANZSIC (UN, 2016). For example, fuel use by residents not on the territory (eg international flights departing overseas) would be included in the SEEA energy accounts but not in the energy balance tables. These adjustments would enable alignment to the GHG by industry and household account and wider economic statistics.

The general structure of energy physical flow accounts is shown in appendix table A1. These accounts can also be compiled in monetary terms, which may show the significance of energy costs in relation to other expenditures, and therefore whether an industry has the capacity or constraints to reduce emissions.

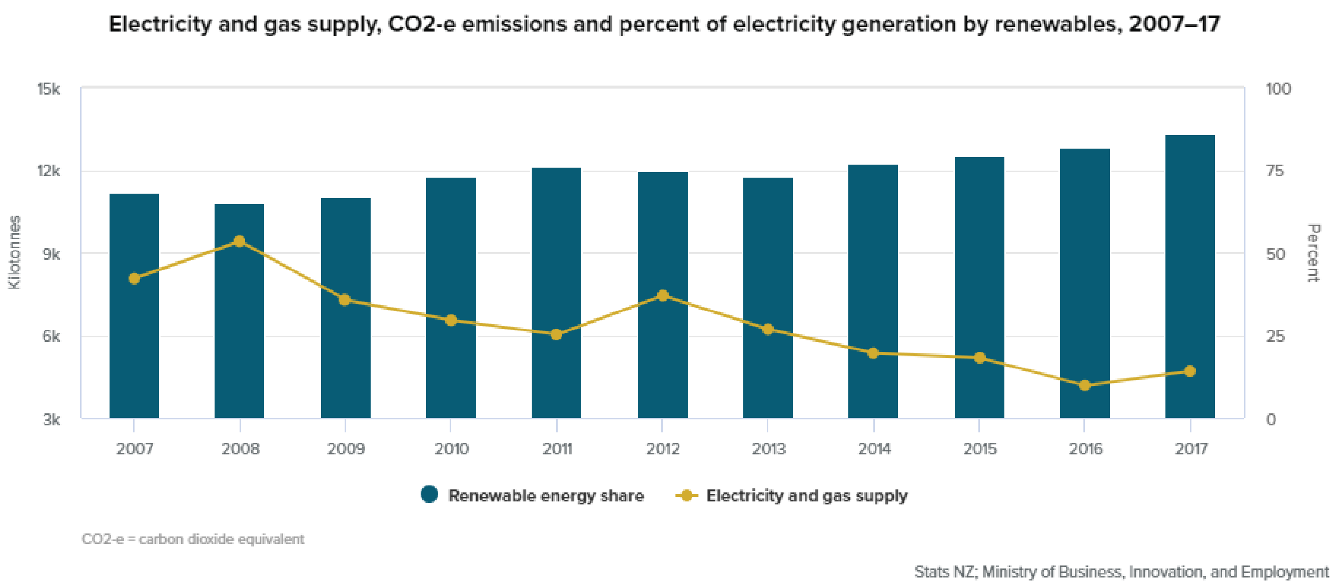
Energy accounts could also be used to derive indicators, such as carbon dioxide productivity, or enable further decompositions that illustrate the drivers of emissions intensity to be developed (such as the role of energy intensity and fuel mix).

Electricity and gas supply

Emissions from the electricity and gas supply industry showed a significant downward trend from 2007–17, decreasing 5.3 percent a year (figure 21), and showing the greatest reduction in emissions. This was largely driven by the increasing proportion of electricity generated using renewable resources such as hydro, geothermal, and wind.

Hydro generation has remained relatively steady at around 55 percent of total electricity generation, but total generation from renewables increased from 68 percent to 86 percent over the period. This increase was driven mainly by increases in geothermal generation.

Figure 21

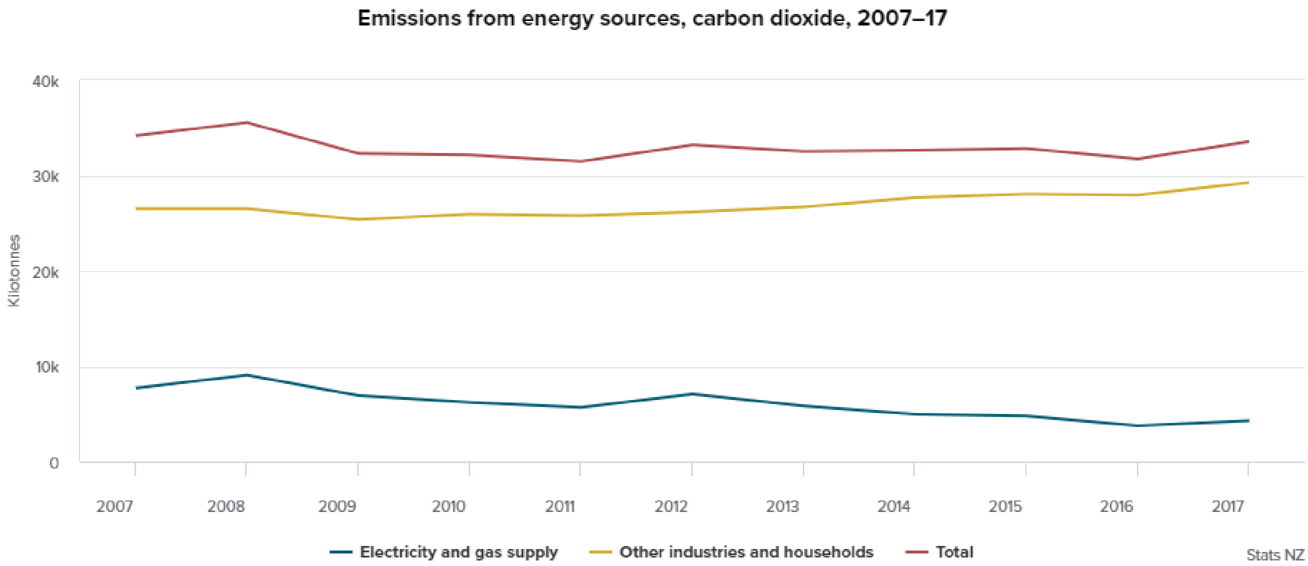


Emissions from electricity and gas supply are new to this release. In *Environmental-economic accounts: 2018*, emissions were only available for the electricity, gas, water, and waste services industry. Electricity and gas supply emissions account for 5.7 percent of total emissions, while emissions from water, sewerage, drainage, and waste services account for 2.2 percent. Most of the decrease in emissions from the electricity, gas, water, and waste services industry came from electricity and gas supply. However, water, sewerage and drainage service emissions decreased at a rate of 2.3 percent a year from 2007–17.

Increased emissions in electricity and gas supply in 2008 and 2012 may correspond with dry years, which led to the increased use of generation from non-renewable sources. The water physical stock account shows decreases in precipitation in the June years 2008 and 2012. Generation from hydro was at the low end of seasonal expectations for the June 2008 and 2012 quarters, while generation from coal and gas increased.

Increased use of renewable energy sources contributed to the decline in emissions in the electricity and gas supply industry, but total energy emissions (SEEA basis) has remained constant since 2007, given increasing energy use and emissions in other industries (figure 22). Data from the energy balance tables (MBIE, 2018) shows the share of electricity to total energy produced for consumption remained at about 25 percent over time. Electrification of energy for activities such as transport, use of renewable energy sources, and improved energy efficiency of appliances and other products may affect the energy emissions profile in time.

Figure 22



Household emissions

Emissions by New Zealand's households increased 19.3 percent from 2007–17, contributing 11 percent to total emissions in 2017 (figure 23). This led to household's contribution increasing from 9 to 11 percent of total emissions. Direct emissions by households include:

- road transport
- heating and cooling – include direct fuels burnt (eg wood for heating, and refrigerants for cooling)
- other sources – primarily household use of septic tanks.

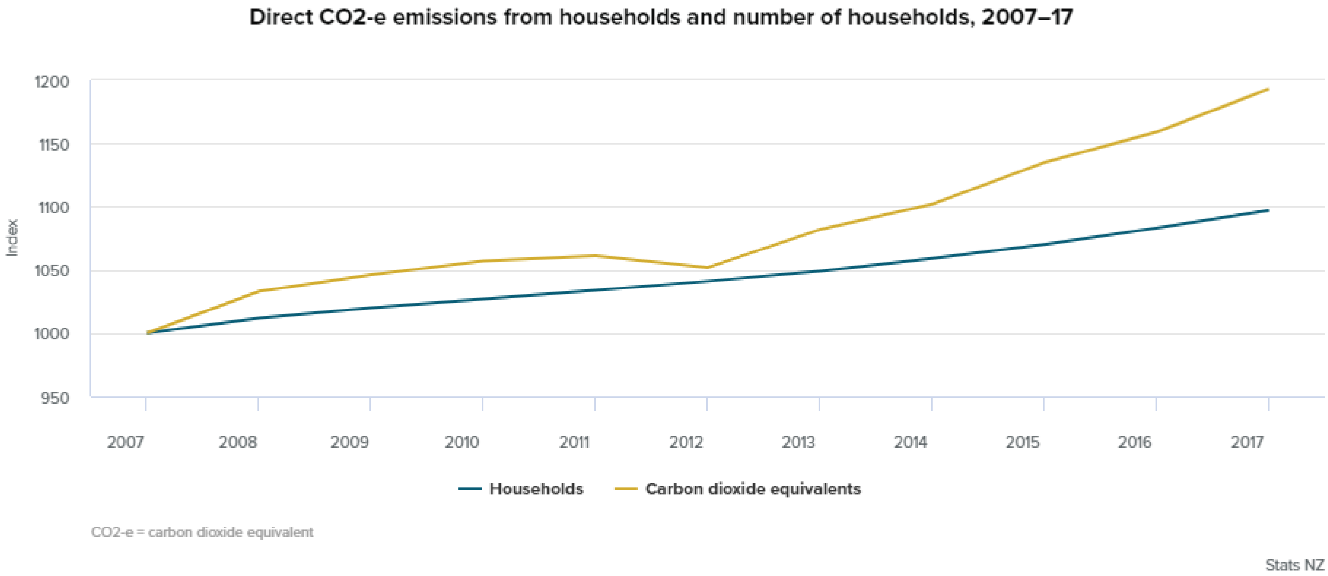
Carbon dioxide is the predominant gas emitted by households, mainly from road transport. However, in addition to methane and nitrous oxide, households also emit hydrofluorocarbons from mobile air conditioning, metered dose inhalers and refrigerants.

Road transport accounts for most direct emissions by households, accounting for 89.1 percent in 2017. Use of fuels for heating and refrigerants for cooling accounted for a further 7.7 percent, and other sources 3.2 percent. Household emissions (up 19.3 percent from 2007–17) increased at a faster rate than the number of households, particularly from 2012 (up 9.7 percent from 2007–17). This implies households are less efficient at managing direct emissions.

The census night count of occupied dwellings increased 0.9 percent a year from 2006–13, and 1.6 percent a year from 2001–06 (Stats NZ, 2013a). Population projections show household numbers are expected to continue growing 0.9 percent a year between 2018 and 2038 in line with changes in living arrangements.

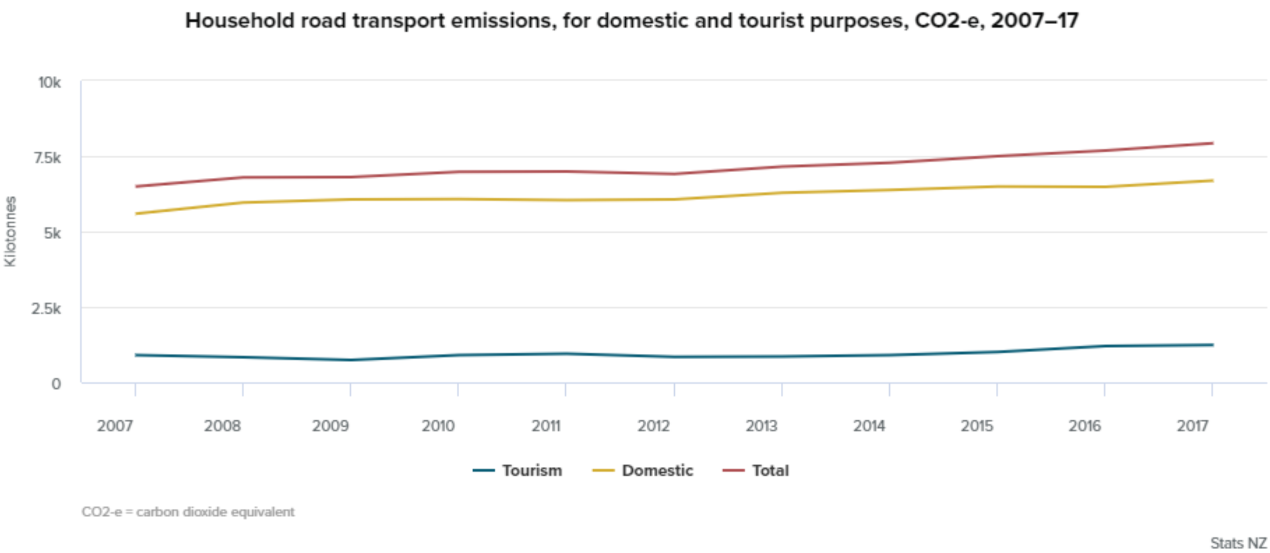
The census definition of a household is either one person who usually lives alone, or two or more people who usually live together and share facilities (such as for eating or cooking) in a private dwelling. In 2013, the average household size in New Zealand was 2.7 people per household, the same as in 2006. In 2013, most households consisted of one or two people, with households with one or two usual residents making up over half of New Zealand households. This showed little change since 2001 (Stats NZ, 2013b).

Figure 23



Households use vehicles mainly for domestic use (eg commuting), but the share of emissions attributable to tourism within New Zealand has increased in recent years. Figure 24 shows how household use of vehicles for domestic tourism purposes reached 1,240 kilotonnes in 2017 and accounted for 15.6 percent of total household road transport emissions.

Figure 24

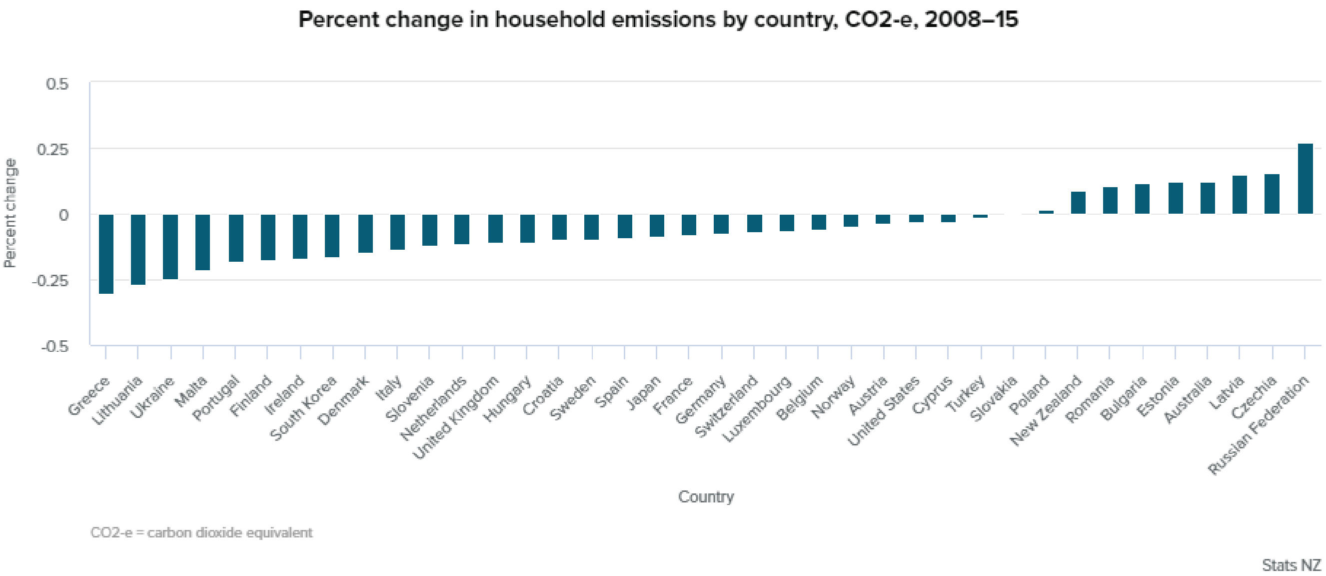


Direct emissions by households capture those directly attributable to households from production. This does not capture indirect emissions associated via the purchase of goods, either produced domestically or internationally, or using energy via the grid. Previous estimates of New Zealand's consumption measure have focused on household consumption, breaking it down into income groups (Kerr & Allan, 2014). This can provide insight into the behaviour of different income groups, the effect that emissions pricing may have on different households, and their ability to change behaviour (eg affordability of electric vehicles).

International comparisons

For the 38 countries for which comparable data were available for 2008–15, growth in emissions by New Zealand households were among the highest (up 9.2 percent). This was surpassed only by Russian Federation, Czechia, Latvia, Australia, Estonia, Bulgaria, and Romania (figure 25). On average, households contributed 16.2 percent to total emissions in 2015.

Figure 25



Tourism emissions

The SEEA approach identifies and allocates emissions according to the residence of the business or household, and so accounts for the following emissions.

- Emissions on domestic territory by non-residents, such as international tourists hiring campervans, are excluded. These emissions are implicitly included in the Greenhouse Gas Inventory in the energy sector.
- Emissions by residents not on the territory, such as international air and shipping transport by New Zealand companies. These are outside the scope of the Greenhouse Gas Inventory.

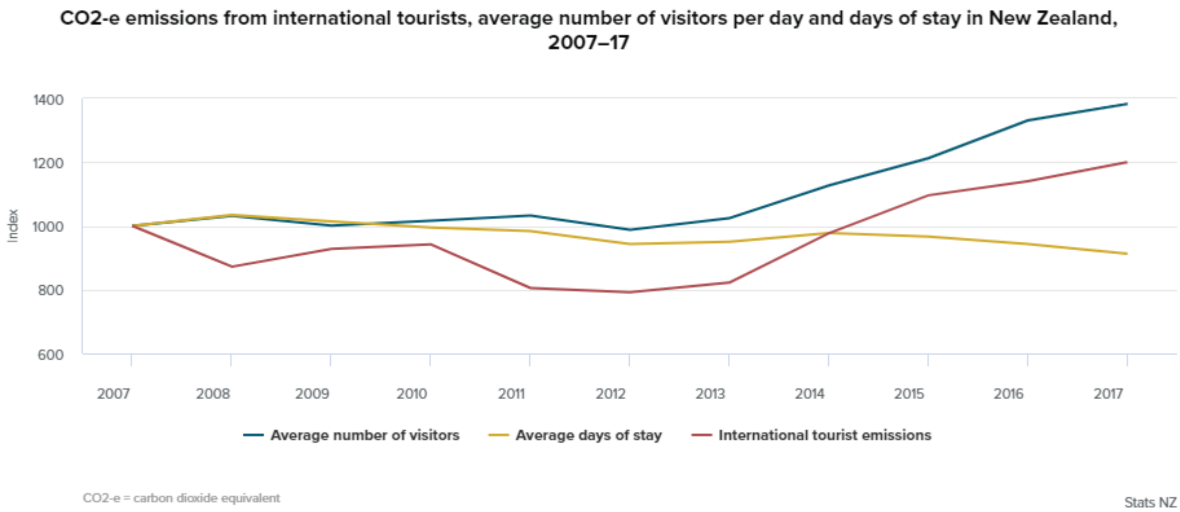
Tourism, which entails activity across many service industries (particularly rental and hiring services, transport, accommodation, and arts and recreation), makes a significant contribution to GDP. Tourism generated a direct contribution of $15.9 billion to GDP in the year ended March 2018, or 6.1 percent of GDP (Stats NZ, 2018). Total tourism expenditure amounted to $39.1 billion, of which $16.2 billion was from international tourism expenditure. International demand for retail sales of fuel and other automotive products totalled $680 million in 2018. Petrol, diesel, and other fuels purchased by international tourists accounted for 6.3 percent of total supply in 2018.

Tourism emissions, primarily from fuels used for road transport, amounted to 1,153 kilotonnes of carbon dioxide equivalents in 2017, up 20.0 percent since 2007. These emissions equated to 1.4

percent of the Greenhouse Gas Inventory total gross emissions. Emissions from fuel used for road transport amounted to 7.8 percent of total road transport emissions. Fuel expenditure by tourists is mainly on diesel, which has a higher emissions factor than petrol. This means the relative contribution of tourism emissions from road transport per dollar spent is higher.

Information on emissions from international tourists reflects growth in the average number of visitors in New Zealand since 2007 (figure 26). The average number of visitors in New Zealand per day increased 38.3 percent from 2007–17, to an average of 188,168 in 2017. Average length of stay decreased, but this does not seem to be affecting emissions, suggesting more intensive use of road transport per day.

Figure 26



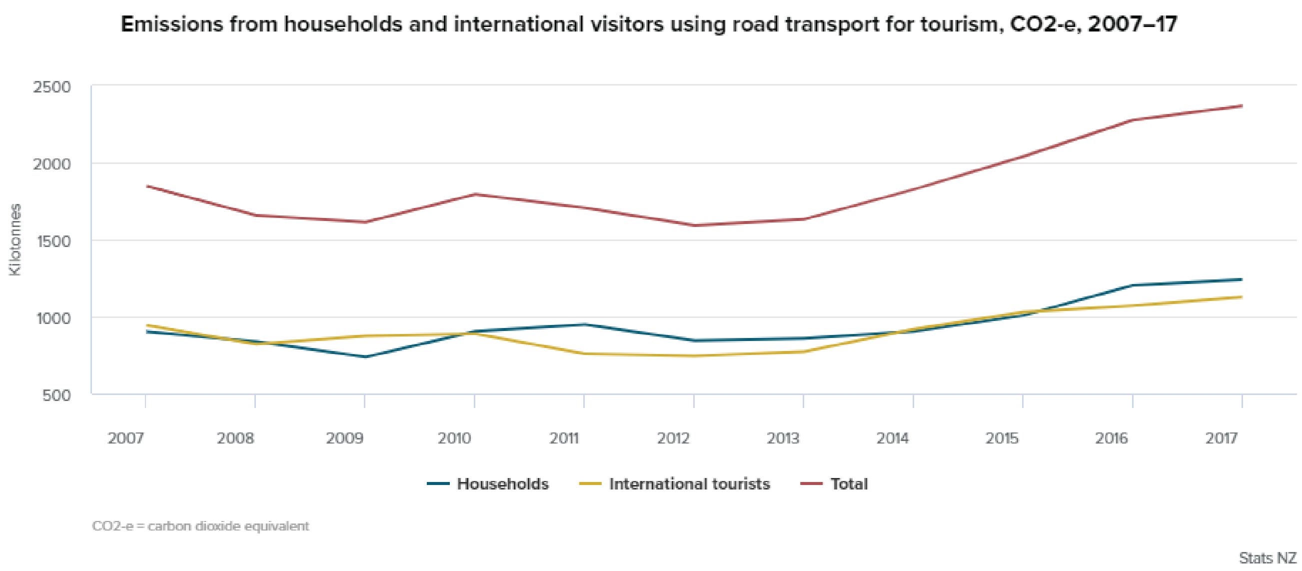
Factors that may contribute to emissions from tourists include:

- preferences and reasons for travel
- availability of substitutes (eg electric vehicles or other transport modes).

Estimates of the average number of visitors to New Zealand include those entering via cruises who are less likely to hire vehicles. About 8 percent of visitors arrived in New Zealand via cruise ships. Emissions from cruise ships are not accounted for in the greenhouse gases by industry and households account as the cruise operators are not New Zealand resident companies. New Zealanders' emissions overseas are also not accounted for, due to the absence of information on overseas fuel use. This may represent a growing data gap, as New Zealand residents' departures increased steadily from 2007–17.

Direct emissions from tourism also arise from New Zealand households' use of vehicles within the country. Figure 27 shows New Zealand household emissions using road transport for tourism follow those from international tourists.

Figure 27



The emissions reflect those directly attributable to international and domestic tourists who use road transport. They do not include indirect emissions associated with travel (such as through accommodation), or other energy use, or other modes of travel (such as water or rail).

Emissions from accommodation and food services; transport, postal, and warehousing; and recreation services could, with development, be allocated to tourism. Estimating consumption-based emissions may further identify the role of tourism on emissions, particularly by assessing the contribution of tourism to the emissions from accommodation and food services; transport, postal, and warehousing; and recreation services industries.

Emissions by tourism related to other transport forms are likely to be significant. The rail, water, air and other transport industry accounted for 5.5 percent of total carbon dioxide equivalent emissions in 2017. The consumption-based approach would consider emissions from the perspective of residence of the passenger, rather than the operator, which will be particularly significant for aviation.

The United Nations World Tourism Organisation (nd) provides some guidance on how energy, water, waste, and greenhouse gas accounts for tourism may be compiled. A tourism account for greenhouse gas emissions would include the total emissions of those industries that have a high contribution to tourism, along with a breakdown of the emissions specifically allocated to tourism within those industries. Industries related to tourist activity include the accommodation and food services; transport, postal and warehousing; and arts and recreation. An example of the information which may be shown in a full greenhouse gas tourism account is shown in appendix table A2.

Carbon sequestration and the role of forestry

The previous section discussed the pressures placed by industries and households in producing emissions. These emissions can be offset through carbon sequestration, the process by which carbon dioxide is removed from the atmosphere. Forests play a key role in sequestering carbon in New

Zealand, particularly fast-growing cultivated forests, planted with the primary purpose of provisioning timber.

In 2017, the forestry and logging industry accounting for 0.6 percent of GDP in 2017. Forestry activity, however, spans both the forestry and agriculture industries. The agricultural production survey shows 89.8 percent of agricultural land defined as plantations of exotic trees intended for harvest was operated by units classified to the forestry industry in the year ended June 2017. The balance was spread across the sheep, beef cattle, and grain farming, and dairy cattle industries. Of agricultural land under harvested exotic forest area awaiting restocking, 83.4 percent of respondents were in forestry and the balance again spread across the sheep, beef cattle, and grain farming, and dairy cattle industries.

Furthermore, using harvested wood products (HWP) also plays an important role in determining the rate at which carbon captured in timber is returned to the atmosphere. The role of HWP in carbon sequestration is important to consider, given that patterns in wood consumption are influenced by the demand from industries and final users.

This section discusses the extent and trend of carbon sequestration in forests and the role of timber resource use on carbon sequestration. We use the accounting approach to environmental assets to show the change in timber stocks due to additions (eg natural growth), removals (eg harvesting), and the net effect of other changes (eg forest fires). Recording both the additions and reductions that contribute to a net change in the stock is important to understand what may be driving this change, and where meaningful interventions could be made. The amount of carbon stored in forests can be presented in a similar format and compared to data from the timber stock account. This approach also allows information on carbon sequestration (either from forests or the harvested wood product pool) to be integrated with information on timber stocks and flows.

Carbon sequestration in forests

Net emissions of greenhouse gases account for the emissions and removals from land use, land-use change, and forestry (LULUCF). Emissions in the LULUCF sector are caused mainly by the harvesting of timber, deforestation, the decomposition of organic matter, and losses from the pool of HWP. Removals occur primarily from carbon sequestration due to plant growth and increases in the size of the HWP carbon pool.

The LULUCF sector offset nearly one-third of New Zealand's gross emissions in 2017, as measured in the Greenhouse Gas Inventory (MfE, 2019). However, the net carbon dioxide equivalent sequestered by the LULUCF sector decreased 23.1 percent from 1990–2017, from 31,162 kilotonnes in 1990 to 23,958 kilotonnes in 2017. This decrease was largely driven by an increase in timber harvesting, deforestation, and a reduced rate of tree planting. This contributed to an increase in net emissions by 64.9 percent over the period, in contrast to a 23.1 percent increase in gross emissions. Of the emissions sequestered from LULUCF in 2017, 79 percent (18,905 kilotonnes of carbon dioxide equivalent) was from forest land. Given the significance of LULUCF in New Zealand's emissions profile, understanding the extent and capacity for forestry to offset gross emissions is essential for tracking progress towards net emissions targets.

From tonnes of carbon dioxide equivalents to tonnes of carbon

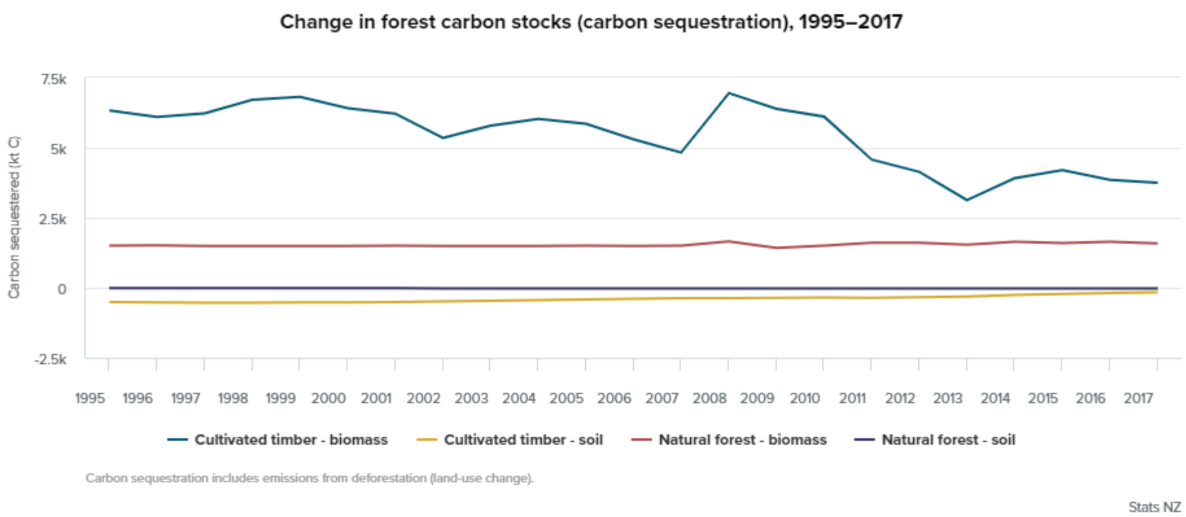
The mass of carbon in the atmosphere is measured in tonnes of carbon dioxide. However, when carbon is sequestered it is stored in a solid or liquid form, and its mass is measured in tons of carbon.

The conversion of carbon to carbon dioxide is based on relative atomic weights. One tonne of carbon is equal to 3.67 tonnes of carbon dioxide.

While a large amount of carbon is stored in natural old-growth (primary) forests (2.6 million kilotonnes in 2017), little additional carbon is being sequestered as forests have reached a steady state (ie there is no growth in the carbon pool). The sequestration that does occur in natural forests is largely from biomass growth in regenerating forests (figure 28). In contrast, while cultivated forests have much lower carbon stock values (502,893 kilotonnes in 2017), they sequester a large amount of carbon each year.

These plantation forests are largely made up of fast-growing exotic trees, which capture a lot of carbon in their biomass. In 2017, cultivated forests sequestered a net of 3,591 kilotonnes of carbon, while natural forests sequestered 1,565 kilotonnes of carbon. The sequestration in cultivated forests has generally been declining since 1995, largely due to an increase in deforestation and the harvesting of timber.

Figure 28



Timber harvesting and carbon sequestration

The large contribution to carbon sequestration from cultivated forests occurs primarily because carbon sequestered in biomass exceeds carbon emissions from soil and harvesting for timber resources. The annual growth in timber volume rose steadily from 1995, reaching 38.7 million cubic metres in 2017. The total volume of timber removed from cultivated forests each year increased steadily from 2005–12, after which it levelled out. In 2017, the recoverable volume of harvested timber reached its highest level, at 26.5 million cubic metres. This difference between growth and harvesting allowed for the standing stock of cultivated timber to more than double from 1995–2017, increasing from 232.6 million cubic metres to 486.8 million cubic metres.

From 2007–17, the volume of timber harvested each year increased at a faster rate than the yearly increases in timber growth. The increase in harvesting has also contributed to a decrease in the carbon sequestered in planted forest stands. The net carbon sequestered per hectare by planted forests each year decreased 19.1 percent from 2007–17.

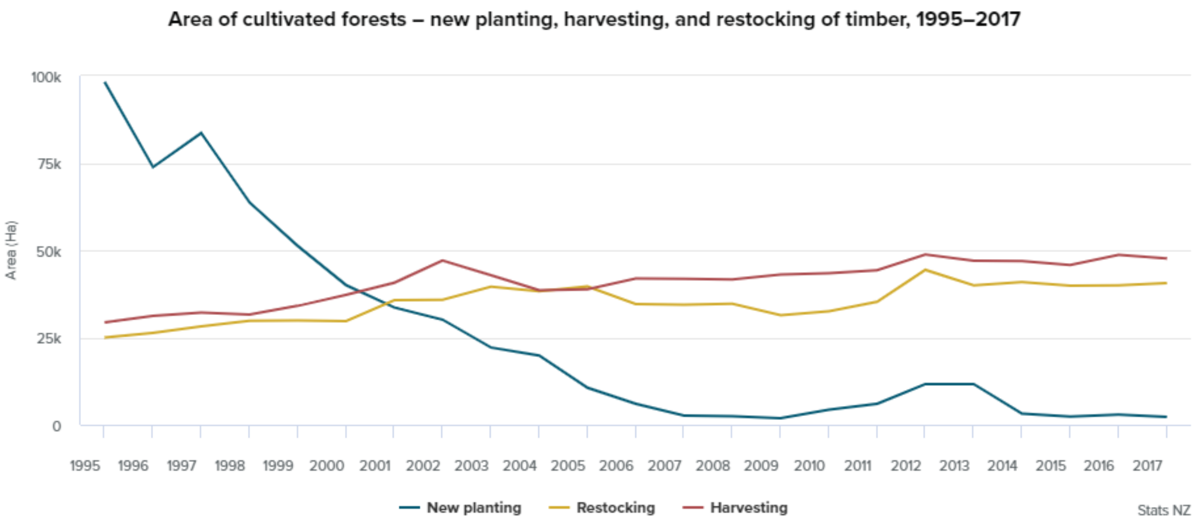
Rate of planting, forest age class, and harvesting rates

The rate of harvesting in cultivated forests depends largely on the timing of planting and subsequent age class of forests. A large amount of new tree planting took place in the 1990s. This allowed for a steady increase in the volume of cultivated timber available for (future) harvesting over this time.

The rate of new planting decreased significantly after the boom in the early 1990s, reaching a low of 1,900 new hectares planted in 2009 (figure 29). Additionally, the area of forest harvested exceeded the area re-stocked every year from 1995-2017 (apart from in 2005), as forest land was replaced for other land uses (eg farming). This has resulted in a general decrease in the total area of cultivated forests, from 1.82 million hectares in 2002 to 1.72 million hectares in 2017.

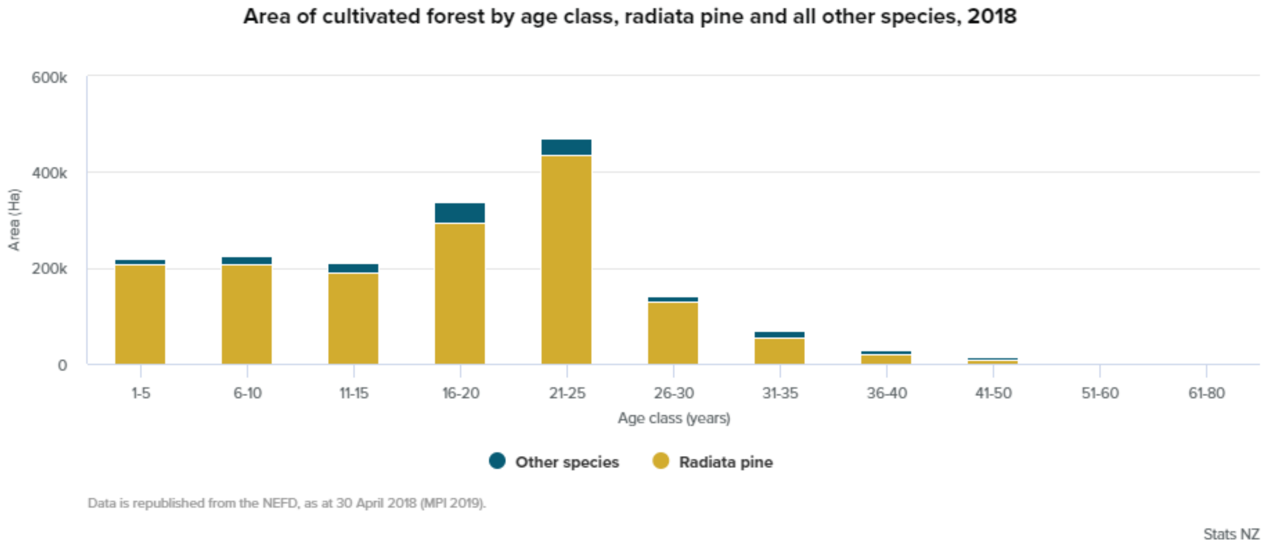
Radiata pine accounted for 90 percent of cultivated forest area in 2017. Radiata pine stands take about 28 years to reach their harvestable age. Due to the high rate of planting that began in the early 1990s, a lot of these planted trees are expected to reach their harvesting age soon, in what has been termed as 'the wall of wood'. As these forest stands reach their age of harvesting, the rate of harvesting is expected to increase.

Figure 29



The decrease in the rate of new planting since the 1990s has resulted in an uneven distribution in the age class of planted forests. The distribution of forest area by age class for 2018 is shown in figure 30. The large area of trees in the 21–25 age class will soon reach harvesting age. The decrease in forest area stands aged 26 years and over was due to harvesting.

Figure 30



1 July 2019: The version of figure 30 published on 27 June 2019 had incorrect x-axis labels (showing age class (years)). The first three columns from the left were labeled 1-May, 6-Oct, and Nov-15. We've corrected these to 1-5, 6-10, and 11-15, respectively.

Potential implications for carbon sequestration in forests

If the rate of harvesting increases as more planted forest stands reach maturity, the amount of carbon sequestered in planted forests will likely decrease. The rate of harvesting of timber when it reaches a suitable age will likely depend on a number of factors. These include the necessary infrastructure required to access mature forest sites and the current price of timber. Other factors, such as the price of dairy products, may also influence if harvested timber land will be restocked, or converted to other more economically desirable land uses. Additionally, the price of New Zealand units of carbon sequestered under the Emissions Trading Scheme and initiatives such as the One Billion Trees Fund may also influence afforestation and harvesting rates.

Use of timber resources in the economy

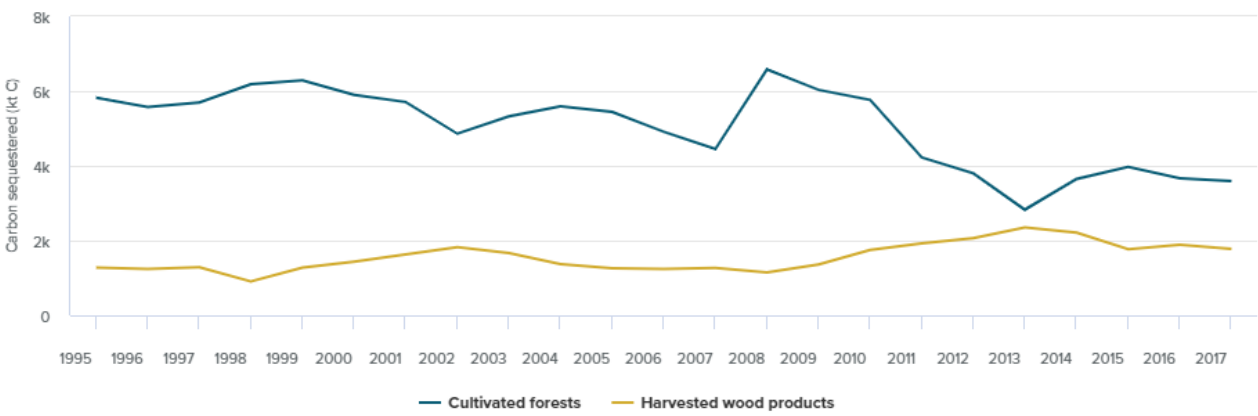
Understanding the final use of timber products, as well as the rates of timber harvest, will be important for tracking progress towards a low-emissions economy. SEEA's physical flow account for timber products records the supply and use of timber products within the economy (eg from the forestry and agriculture industries to wood and paper products, printing, construction, and furniture manufacturing) and the role of imports and exports. This can be a useful tool to understand how timber products are being used, and the implications this use may have for long-term carbon sequestration as the amount of sequestration from harvested wood products depends on its final product use. The physical flow account for timber products is currently an area for future development.

When timber is harvested, the carbon it has sequestered is not immediately released back to the atmosphere. While there are some losses, most of the carbon remains in the wood, entering the carbon pool of harvested wood products (HWP). The HWP carbon pool includes wood from domestic production and wood for export. As the harvesting of timber increases, the net sequestration in forests will tend to decrease. The carbon stored in harvested timber then enters the carbon pool of HWP, which will then tend to increase (figure 31). The HWP pool makes a large contribution to the removals of carbon dioxide from the LULUCF sector, accounting for a net removal -6,518.5 kilotonnes carbon dioxide equivalents in 2017.

The sequestration of carbon in the HWP pool will depend on the rate of harvest and the estimated lifespan of a given timber product before it is discarded. The type of product harvested timber is converted to, and the efficiency in which this is done, can have an important influence on the net carbon sequestration from HWP.

Figure 31

Carbon sequestration in cultivated forests and harvested wood products, 1995–2017



Sequestration in cultivated forests includes emissions from soil and deforestation.

Stats NZ

Carbon sequestration in harvested wood products

The net change in the carbon pool of harvested wood products is the difference between gains (from the immediate harvesting of timber which adds more timber to the pool of harvested wood products) and losses (from the decay of timber products) (figure 32).

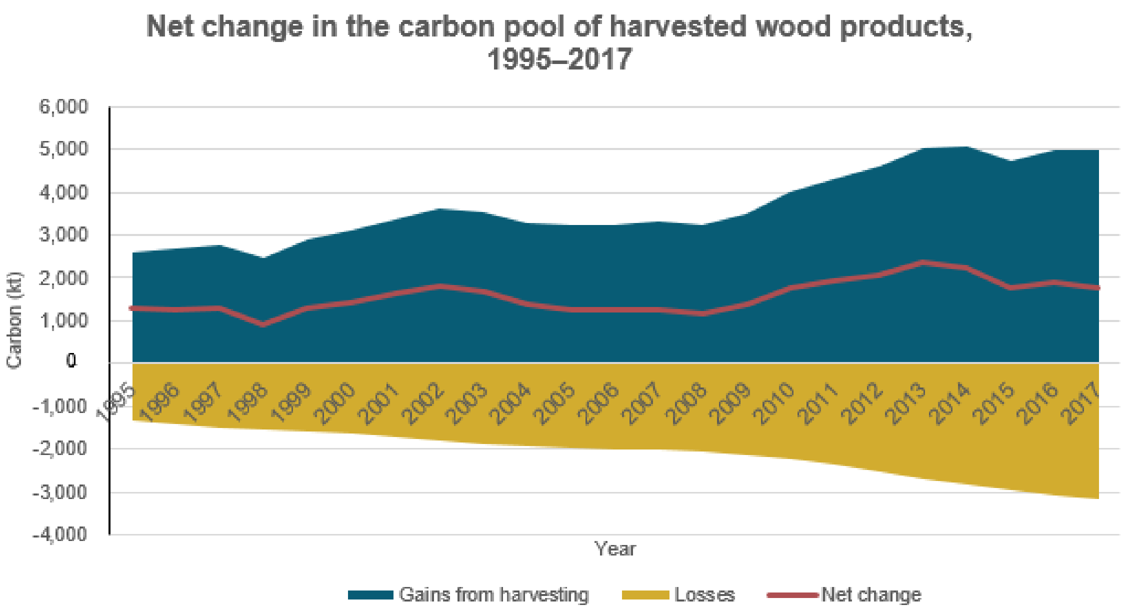
Losses are determined by the life cycle of timber products. While the timber is in use, its carbon remains locked up. However, once the wood product is no longer in use it will often end up in landfills or be burned, causing the carbon to be released back to the atmosphere (although some timber products are recycled).

The life cycle of a given timber product is determined by an estimated half-life. This represents the rate of '**decay**' at which half the carbon sequestered in a timber product is assumed to be lost.

Different types of timber products have different half-lives. For example, sawnwood assumes a half-life of 35 years while paper and paperboard products have a half-life of two years (IPCC, 2014).

Data on harvested wood products is taken from the New Zealand Greenhouse Gas Inventory (MfE, 2019). The approach and calculations we used are consistent with their reporting.

Figure 32


Net change in the carbon pool of harvested wood products, 1995–2017
6,000
5,000
4,000
3,000
2,000
1,000
0
-1,000
-2,000
-3,000
-4,000
Carbon (kt)
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Year
Gains from harvesting
Losses
Net change

Impacts

Present levels of carbon dioxide and other greenhouse gases from human activities have already led to climate change, and further increases will lead to further global warming. The environmental-economic accounting approach highlights the impact of climate change on environmental assets, such as timber, water, and fish. Environmental and policy responses to climate change may also lead to changes in ecosystems, land use, and energy sources.

Understanding the impacts of climate change on GDP will also be of interest. National and regional economic accounts are needed for this, but attributing changes in GDP to climate changes requires additional modelling. Frame et al (2018) discuss some examples of how the financial costs of climate change may be related through attributing climate-related events to economic activity.

This section outlines how asset accounts for those produced under the SEEA can be useful for monitoring the impact of climate change on environmental assets.

Fire and timber stocks

Fire risks in different parts of the country are likely to increase in the future. The risk for areas already subject to severe fire risk are expected to remain the same. In contrast, areas not currently perceived as high risk may become at risk (such as coastal Otago, the Manawatū area, in and around Wellington, and Whanganui). This may not necessarily result in more fires, but in an increased number of fire-risk days in a season and to the length of that season (Scion & NIWA, 2011).

Fire affects both commercial exotic forestry and native trees on protected land, affecting the stock of wood available for supply or other ecosystem services from forest land. We report on the number of hectares of forest affected by fires annually for cultivated and natural forests. In some cases, wood may be recoverable after a fire if it is able to be promptly harvested. Estimates of the resulting timber loss is not available from the current timber monetary stock account, as estimates for the amount which can be recovered following fire cannot be determined yet.

In 2017, fires affected just an estimated 359 hectares of the total 1.72 million hectares of cultivated forests, which had a total timber stock value of $23.1 billion.

Given the extent of fires and timber that may be recovered, the impact of fire may be more significant for losses of ecosystem services. Losses of carbon in timber from fire can also result in a loss of ecosystem services of carbon sequestration and storage, as well as other regulating or cultural ecosystem services.

Assessing the impacts of climate change through ecosystem accounts

Climate change impacts on New Zealand may be observable in future asset accounts but may also be captured in future developments of ecosystem accounts.

Ecosystem accounts include the extent, condition, and services of ecosystems at a defined spatial scale. Ecosystem services reflect the contribution of ecosystems to the benefit of people, and therefore the impact of environmental assets on wellbeing.

Ecosystem service flows are classified into three broad categories:

- provisioning services (eg material and energy provided by ecosystems, such as timber, fish, or plants),

- regulating services (capacity of ecosystems to control climatic, hydrological, and bio-chemical cycles)
- cultural services (eg recreation).

The benefits received from ecosystem services may include goods and services produced within the economy and recorded in the system of national accounts (eg timber harvest or fish caught).

Alternatively, they may include non-market benefits which are not covered in the national accounts (eg clean air and carbon sequestration). Both these types of benefits contribute to individual and societal wellbeing.

In the context of climate change, here are how the ecosystem accounts can be useful.

- Assess the impact on ecosystem extent, condition, and services in a spatially explicit manner. This allows focus to be given to specific regions which may differ in their climate change impacts (eg changes in rainfall patterns), or to certain ecosystems that may be more susceptible to climate change impacts.
- Assess the change in services provided by ecosystems following land use change decisions to mitigate or adapt to climate change (eg forested land).
- Assess where climate change impacts occur (eg drought), along with responses intended to mitigate these (eg afforestation), in relation to where people live and the economic activity they depend on.
- Enabling decision-making to optimise the range of ecosystem services for a given land use. For example, afforestation with the primary purpose to sequester more carbon may also provide a suite of additional ecosystem services.

Asset accounts for biodiversity (one of four thematic accounts described in the SEEA experimental ecosystem accounting framework, the others being land, water, and carbon), along with biodiversity indicators within the condition account, may also show the impact of climate change on species sensitive to changes in temperature or other climate conditions.

Bond and Vardon’s (2018) ‘butterfly accounts’ summarise the number and status of butterflies found in Australia Capital Territory (ACT) and their conservation status. They show how biodiversity accounts can provide indicators of climate change impacts. Between 1978 and 2018, nine species were added to the list of butterflies found in the ACT and to the categories of range extensions and taxonomic change. Most species added came from range extensions, reflecting the changing Canberra landscape where the creation of parks and reserves have increased floristic diversity. Another change in range noted may be driven by climate change with species formerly considered vagrant and migrant, such as the flame sedge-skipper, which established resident populations due to changed weather conditions, specifically milder winters.

In categorising species into generalists or specialists, accounting surrogates for environmental condition emerged. In this context, generalists were defined as having a widespread distribution, several breeding and foraging habitats and/or several plant species for their larval food plant preferences. Specialists have localised or restricted distribution, one or two breeding and foraging habitats, and only one or two plant species suitable for their larval food plant preferences.

Using this approach, it was suggested that generalists were sufficiently widespread to be useful indicators of climate change, while nominated specialists could be used to track environmental condition for any given habitat.

Land cover, land use, and management

Climate-related impacts on fire, precipitation, temperature, air circulation, wind speeds, and storms will alter the makeup of the land cover of New Zealand and affect the type of land use best suited to an area.

The land cover account (released in 2018) showed that 2.3 percent of New Zealand's land cover changed classes from 1996 to 2012. Tree-covered areas increased 199,547 hectares (2.2 percent), grassland cover decreased 214,581 hectares (1.6 percent), and artificial surfaces increased 24,220 hectares (10.9 percent). Some of this change was due to economic considerations and some to population growth and demographic patterns, but future account updates are likely to show increased effects of land cover change due to climate change. Additionally, flood risk and magnitude may increase in some areas and pest species, particularly plant pests, may increase their range and impact.

The environmental protection expenditure (EPE) account may show changes in final consumption expenditure and investment due to climate change in these categories: flood, river, land and soil management, and pest management.

Further information that specifically relates to climate change adaptation or mitigation may be able to be presented in the EPE account in the future and show its effects on regional and national expenditure.

Water resources

Climate change may also affect the availability of water resources, and in turn the availability of water for economic production or households.

NIWA's (nd) climate change scenarios for New Zealand, with the latest based on the IPCC 5th Assessment report, shows mean precipitation (rain, hail, sleet, and snow) change is projected to vary around the country and by season with annual patterns of increases in the west and south of New Zealand and decreases in the north and east. We also expect over time to show the eventuality of these changes in the water physical stock account, which is available regionally based on growing seasons (ie years ended June 30). Consideration of the development of a quarterly presentation of this account will help with understanding and even forecasting the effects of altered precipitation on the economy.

Currently, hydro generation accounts for around 60 percent of electricity generation. In 2017, returns to electricity operators from the use of all renewables (resource rent or the income over extraction costs) was $795 million, $569 million of which was from hydroelectricity. Changing hydrological conditions may affect both returns to electricity operators as well as emissions from the electricity and gas supply industry.

Ocean acidification and fishing

Our oceans have become more acidic by absorbing and storing the high levels of atmospheric carbon dioxide. Ocean acidification may cause widespread harm to New Zealand's marine ecosystems, particularly to marine organisms with carbonate shells like pāua, mussels, and oysters (MfE & Stats NZ, 2016). These organisms include plankton, which form the base of the marine food chain, and other species harvested for customary, commercial, or recreational purposes.

Such changes in the marine environment may impact on the fishing industry and others that use the marine environment. The fishing industry is relatively small in terms of its contribution to the economy, but exports and the associated asset value of commercial species are significant. Many fish species in New Zealand's waters are also important for customary users and recreational pursuits.

In 2017, the fisheries and aquaculture industry contributed $1.1 billion (0.4 percent) to GDP. Also, in 2017, 14,712 wage and salary earners were employed in the combined fishing and aquaculture and seafood processing industries.

In 2018, seafood exports contributed $2.0 billion in export earnings to the New Zealand economy, a 48 percent increase from $1.4 billion in 2003. In the September 2018 year, the calculated asset value of New Zealand's commercial fish resource was $8.8 billion.

Ongoing production of the fish monetary stock account will be important to monitor climate impacts on the commercial fish resource. In the shorter-term, competition for the available catch may drive up access prices, so it will be important to supplement the monetary stock account with a counterpart physical stock account.

Responses

The environmental accounting framework can be used to show economic and societal responses to climate change. It is designed to measure environment-economy interactions across countries, recording responses on the extent to which the main mechanism (eg fiscal instrument) is being used, not country-specific policies.

The effectiveness of these responses cannot be directly ascertained via the accounts but may be considered alongside other relevant information. Relevant accounts for understanding responses to climate change include environmental taxes, emissions permits, and fossil fuel subsidies. These accounts consider response in the sense of climate change mitigation. Adaptation may, in time, be reflected in environmental expenditure accounts.

Greenhouse gas emissions and environmental taxes

Environmental taxes reflect efforts by governments, on behalf of society, to influence the behaviour of producers and consumers with respect to the environment. There is considerable interest in the use and effectiveness of these taxes as they show a direct response of countries to manage environmental change through economic instruments, meeting dual targets of environmental and economic management.

Environmental taxes are taxes with a base that is a physical unit (or a proxy of a physical unit) of something that has a proven, specific negative impact on the environment. These tax bases are:

- energy taxes on energy production and on energy products used for both transport and stationary purposes
- transport taxes related to the ownership and use of motor vehicles and on other transport
- pollution taxes on the management of waste
- resource taxes on raw materials or extraction of minerals, oil, and gas.

Environmental taxes are often thought of as Pigouvian taxes, which are defined as those directed toward negative externalities. Under the SEEA approach, a tax may be defined as environmental even if it is not directed at reducing negative externalities. An environmental tax may also include those which are used to raise revenue for other (non-environmental) purposes if the tax base is something that has a negative impact on the environment.

The precise motivation for tax collection may be difficult to ascertain. For this reason, the SEEA focuses on the underlying tax base (United Nations, 2014). In New Zealand the tax system is not generally used to modify behaviour, except for alcohol and tobacco excise taxes which aim to discourage drinking and smoking (Tax Working Group, 2019). Road user charges are defined as an environmental tax even though the revenue is hypothecated (allocated) for road maintenance.

In 2017, the total amount of environmental taxes (energy, transport, resource (including harvesting of biological resources and extraction of raw materials), and pollution taxes) was $4.8 billion, nearly three times that for 1999 ($1.6 billion). This was 5.5 percent of all revenue from taxes and social contributions received by general government, up from 4.6 percent in 1999. Resource taxes declined from 8 percent of total environmental taxes in 1999 to 1 percent in 2017. In 2017, most environmental taxes were energy taxes (48 percent) and transport taxes (50 percent). Combined pollution and resources taxes made up only 2 percent of the total.

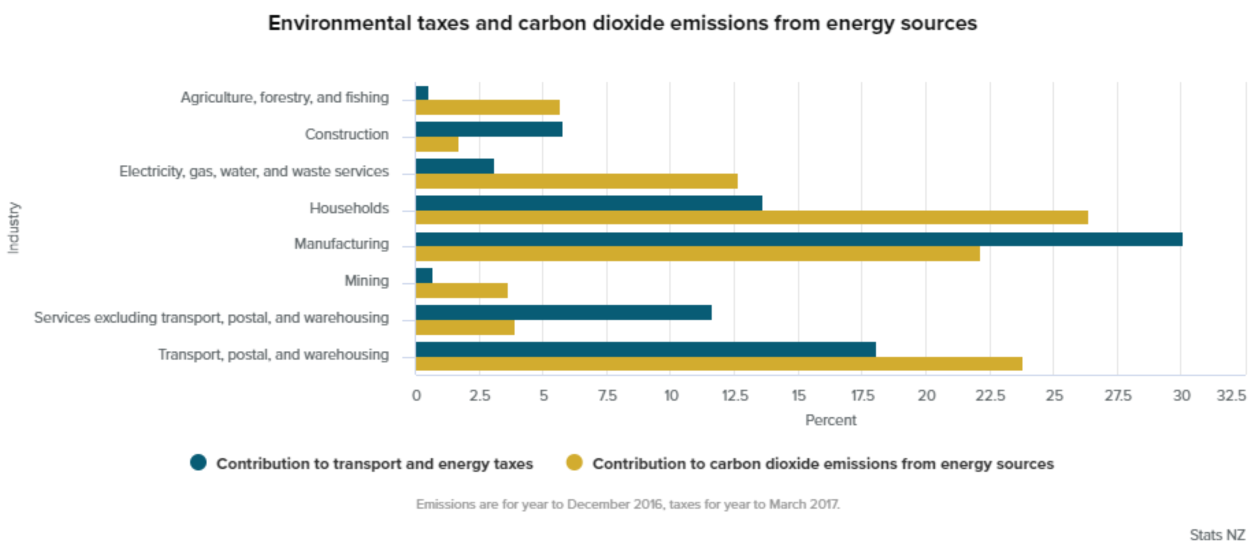
Figure 33 compares environmental taxes (energy- and transport-related) to carbon dioxide emissions from energy sources. We chose the taxes and gases to make the closest alignment between taxes and emissions. Emissions of methane, nitrous oxide, and fluorinated gas are also excluded.

In 2018, Stats NZ updated the treatment of ETS transactions to be more aligned with international national accounts standards for the treatment of carbon credits. Specifically, the tax level is set to zero when the government allocates credits to emitters under the ETS but does not require payment; this treatment is replicated in the environmental taxes account. For this reason, ETS taxes do not appear in the environmental tax account table (see Environmental-economic accounts: 2019 – tables). Pollution taxes, such as the waste disposal levy, are excluded as these may be more related to methane.

In general, industries with higher carbon dioxide emissions pay higher energy and transport taxes, except in the following cases.

- Agricultural carbon dioxide emissions are greater than its tax contribution – mobile (off road) emissions that use diesel are not subject to road user charges.
- The direct tax burden is highest for manufacturing, which has the second-highest energy emissions. However, the petroleum, chemical, polymer, and rubber product manufacturing industry pays excise taxes on behalf of consumers. As this tax is passed on at the pump, households and other industries may ultimately pay some of this tax.

Figure 33



Emissions permits

The Emissions Trading Scheme (ETS) is New Zealand's main scheme for reducing greenhouse gas emissions. ETS puts a price on GHG emissions to create a financial incentive for businesses that emit GHGs to invest in technologies and practices that reduce emissions.

ETS also encourages forest planting by allowing eligible foresters to earn New Zealand Units (NZUs) as trees grow and absorb carbon dioxide. ETS requires all sectors of the economy to report on their emissions, and, except for biological emissions from agriculture, to purchase and surrender emissions units to the Government for those emissions. Just over half of New Zealand's GHGs are covered by ETS' surrender obligations. An emission unit represents one metric tonne of carbon dioxide, or the carbon dioxide equivalent of any other GHG.

Presentation of the allocation of emissions permits across the economy is an area for development in environmental-economic accounts. Permits of GHG can be presented as an asset account showing the opening and closing stock of permits and the various changes in the stock through new issues, purchases, sales, and surrenders, using the same industrial classification, or by institutional sector, as other environmental-economic accounts. Tables A3 and A4 in the appendix presents data on permits in millions of tonnes of carbon dioxide equivalents.

Emissions trading permits are recognised as tax revenue within the national accounts framework to the extent to which payment is received by government. In turn, the environmental tax account records taxes paid for tradable emissions permits and categorises these as energy taxes when the permits relate to emissions of carbon dioxide. An emissions permit account includes detail on transactions outside the definition of a tax and so can complement environmental tax account. The example tables in the appendix could also be expressed in currency units if possible.

Fossil fuel subsidies

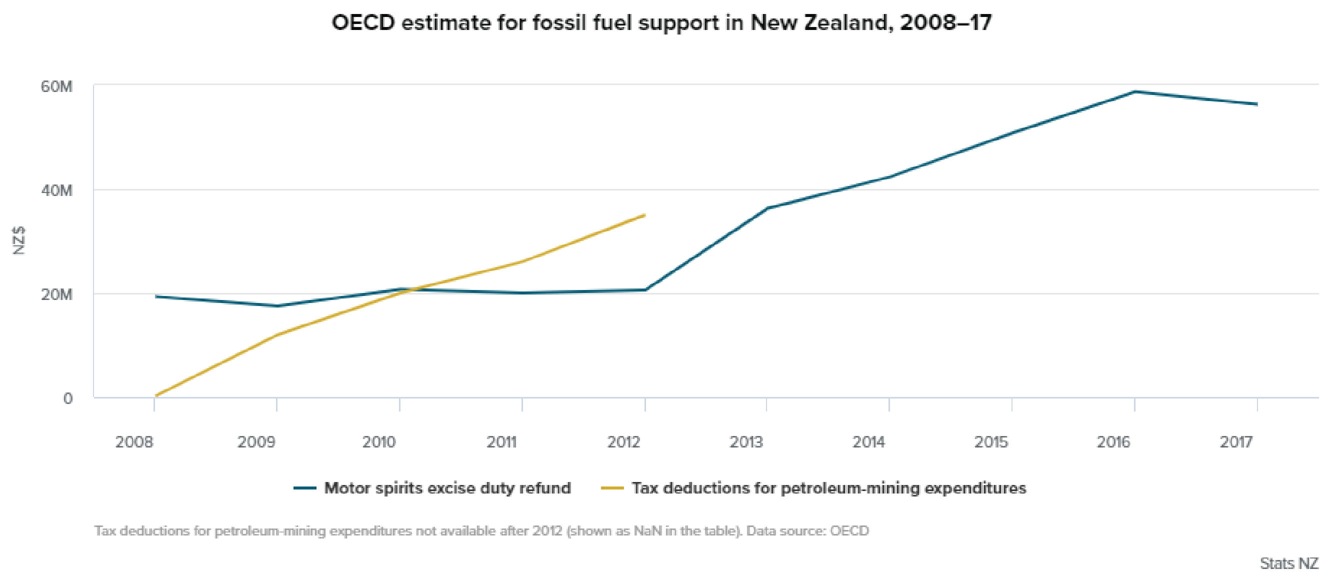
Fossil fuel subsidies can be described as support measures to producers, distributors, or users (consumers) of fossil fuels that can, by reducing the cost of combustion of fossil fuels, create barriers to emissions reduction. These may be broader than the definition of subsidies recorded in the national accounts and prescribed by the SNA 2008 (eg tax credits or tax forgone (exemptions) may be within scope).

Other definitions for subsidies may be suited for different purposes, such as trade negotiations (see Agreement on subsidies and countervailing measures). However, definitions and estimates specific to energy or use of fossil fuels are also emerging (see IEA, World Bank, IMF). Global momentum to reform support to fossil fuels has led to changes in some countries with several countries, including New Zealand, voluntarily undergoing APEC or G20 peer reviews (see APEC fossil fuel subsidy reform peer review).

The OECD produced an inventory of measures for recording the direct support to the production or consumption of fossil fuels in OECD countries (OECD, 2018). It reconciled and combined this information with national estimates of fossil fuel support produced by the International Energy Agency (IEA) for 76 economies that collectively contribute 94 percent of global carbon dioxide emissions. The estimates included support for both consumers and producers. Total estimates of support to fossil fuels range between US$373 billion and US$617 billion over the period 2010–15.

In 2017, the estimated amount of support to fossil fuels in New Zealand was $56 million, down from $59 million in 2016 (figure 34). The estimates for New Zealand include motor spirits excise duty refund from 2008–17 and tax deductions for petroleum mining expenditures from 2008–12. The OECD estimates for motor spirits excise duty refunds appear broadly consistent with those used within Stats NZ's national accounts. Other forms of support applicable to New Zealand were non-resident drilling rig and seismic ship tax exemptions, reductions in royalty payments for petroleum, and exemptions of off-road vehicles from road user charges but data were not available for these items.

Figure 34



A SEEA definition of support for fossil fuels that encompasses other forms of support while retaining consistency with the SNA is still an area for development. The SEEA approach may be able to identify the industries receiving the support as distinct from support to consumers. It is possible to extract information to produce this indicator, but given the possibilities to include various forms of support for fossil fuels and for including other greenhouse gases, agreement will be needed on what to include.

This work, supported by Eurostat, will continue and if successful, development of an approach consistent with the SEEA central framework will be shown in a future revision of the SEEA central framework. Examination of this data will be useful for monitoring a country's own barrier to progress towards a carbon neutral economy and to report on sustainable development goals.

Combined presentation of accounts

Development of industry-level estimates of emissions permits, protection expenditure, and fossil fuel subsidies could be combined with environmental taxes to show the range of fiscal or other instruments used to manage emissions. These could be combined with emissions estimates and other accounts, such as energy, or economic data (such as output, capital stock, employment) to provide a complete picture of the transition to a low-emissions economy using environmental-economic accounting. A comparison of industry level environmental taxes compared with their total taxes on production has been completed and is shown here (see Environmental-economic accounts: 2019 – tables).

Future updates

Here are the environmental-economic accounts available at June 2019 and next planned updates.

Table 5

Environmental-economic accounts available at June 2019			
Name	**Time series**	**Last updated**	**Next planned update**
Physical stocks			
Land cover	1996–2012, regional tables	27 February 2018	TBC
Forestry and timber	1995–2017	27 June 2019	June 2020
Water	1995–2014, regional tables	27 February 2018	TBC
Monetary stocks			
Timber	1995–2017	27 June 2019	June 2020
Fish	1996–2018, QMS species breakdowns	14 February 2019	February 2020
Renewable energy resources	2007–17	14 February 2019	February 2020
Annual resource rents for fish, timber, minerals, and renewable energy	2007–17	14 February 2019 (updated 27 June 2019 for timber)	February 2020
Physical flows			
Greenhouse gases by industry and households	1990–2017	27 June 2019	June 2020
Activity accounts			
Environmental protection expenditure	2009–17	14 February 2019	February 2020
Environmental tax account	1999–17	14 February 2019	February 2020
Other accounts			
Marine economy	2007–17	14 February 2019	February 2020

Revisions to previously published accounts

This section outlines the revisions made to previously published accounts.

Greenhouse gas by industry and households account – revised due to revised input data from the Greenhouse Gas Inventory, and improved methodologies for allocating road transport and other emissions sources that cut across industries and for implementing the economic residence principle.

Timber and forestry accounts – revised due to revised exotic plantation data from the Ministry for Primary Industries. Improved estimates of indigenous timber stocks have been incorporated in the timber account.

Environmental protection expenditure, **marine economy**, **natural capital**, **renewables**, and **environmental taxes accounts** – revised due to improved alignment to the concepts underlying the environmental tax account have led to revisions across the industry allocations series. Industry allocation for environmental taxes have been further revised since the February 2019 table release. This was done to ensure that environmental taxes by industry are consistent when compared with total taxes on production by industry.

Fish monetary stock account– revisions in 2016 were due mainly to the recalculation of the moving average discount rate. Minor revisions in earlier years are due to using deemed values to infill price gaps that would otherwise occur for the most valuable species and eel species.

Accounts for land cover and water physical stocks have not been updated. These are available from *Environmental-economic accounts: 2018.*

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Appendix

Table 1A

A1 Physical use table for energy

Physical use table for energy						
	Intermediate consumption; use of energy resources; receipt of energy losses	Final consumption		Flows to the rest of the world		
	Industry	Households	Accumulation	Exports	Flows to the environment	Total use
Energy from natural inputs						
Natural resource inputs		…	…	…	…	
Inputs of energy from renewable sources		…	…	…	…	
Other natural inputs		…	…	…	…	
Total energy from natural inputs		…	…	…	…	
Energy products						
Transformation of energy products		…	…	…	…	
by type		…	…	…	…	
Total transformation of energy products		…	…	…	…	
Energy products cont.						
End-use of energy products						
by type					…	
Total end-use for energy purposes					…	
End-use of energy products for non-energy purposes						
Energy residuals						
Losses	…	…	…	…		
Other energy residuals	…	…	…	…		
Total energy residuals	…	…	…	…		
Other residual flows	…	…		…	…	
Residuals from end use for non-energy purposes						
Energy from solid waste			…	…	…	
Total use						
Symbol: … not applicable						

Table A2

A2 Example tourism account for greenhouse gas emissions

Example tourism account for greenhouse gas emissions

	Carbon dioxide	Methane	Other gases	Carbon dioxide equivalents
	Emissions allocated to tourism			
Tourism related industries				
Accommodation, food, and beverage services				
Transport				
Arts and recreation				
Total tourism				
	Total emissions			
Tourism related industries				
Accommodation, food, and beverage services				
Transport				
Arts and recreation				
Total tourism				
Other industries				
Households				
Total supply of emissions				

Table A3

Example emissions permits account by industry

	By industry							
	Agriculture	Mining	Manufacturing	Electricity, gas, water, and waste services	Construction	Service industries	Government	Total
Opening stock of permits							…	
Permits allocated free of charge							…	
Permits purchased							…	
Permits sold							…	
Permits earned							…	
Losses (cancelled permits)							…	
Permits surrendered to offset emissions(1)							…	
Closing stock of permits							…	

1. Emissions may be reduced elsewhere to offset the obligation to surrender units.

Symbol: … not applicable

Table A4

Example emissions permits account by institutional sector

	By Institutional sector				
	Corporations[1]	General government[2]	Households[3]	NPISH[3]	Total
Opening stock of permits		…			
Permits allocated free of charge		…			
of which are allocated to industry		…	…	…	
of which are allocated to forestry		…	…	…	
Permits purchased		…			
Permits sold		…			
Permits earned		…			
Losses (cancelled permits)		…	…	…	
Permits surrendered to offset emissions[4]		…	…	…	
Closing stock of permits		…			

1. Ideally disaggregated to NZSIOC level 1 (16 industries).

2. The New Zealand government does not hold permits as to do so would be considered a liability

3. Non-profit institutions serving households (NPISH) and households may purchase units but will not have a registry account - information on these is not currently available from the EPA.

4. Emissions may be reduced elsewhere to offset the obligation to surrender units.

Symbol: … not applicable