Stats NZ
Tatauranga Aotearoa

Approaches to measuring New Zealand's greenhouse gas emissions

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Approaches to measuring New Zealand's greenhouse gas emissions provides an overview of emissions statistics in New Zealand and how they relate to each other. The emissions statistics discussed here include those commonly compiled by countries and produced as official statistics covering multiple source processes at the national level.

We summarise the different approaches countries use to compile emissions statistics and the underlying principles and concepts of each approach, and provide guidance on which approach is appropriate to use and when.

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() Summary of key points

Greenhouse gas emissions statistics are produced using different approaches to meet different demands and applications, and to capture the breadth of factors driving emissions.

For national statistical reporting, countries can measure their emissions using either a production or a consumption approach.

- The production approach records emissions at the point at which emissions pass from human activity to the environment. It has two variations: the territory-based approach and the residency-based approach (see figure 1).
- The consumption approach accounts for emissions 'embodied' in a good or service that result from activity across the entire supply chain.

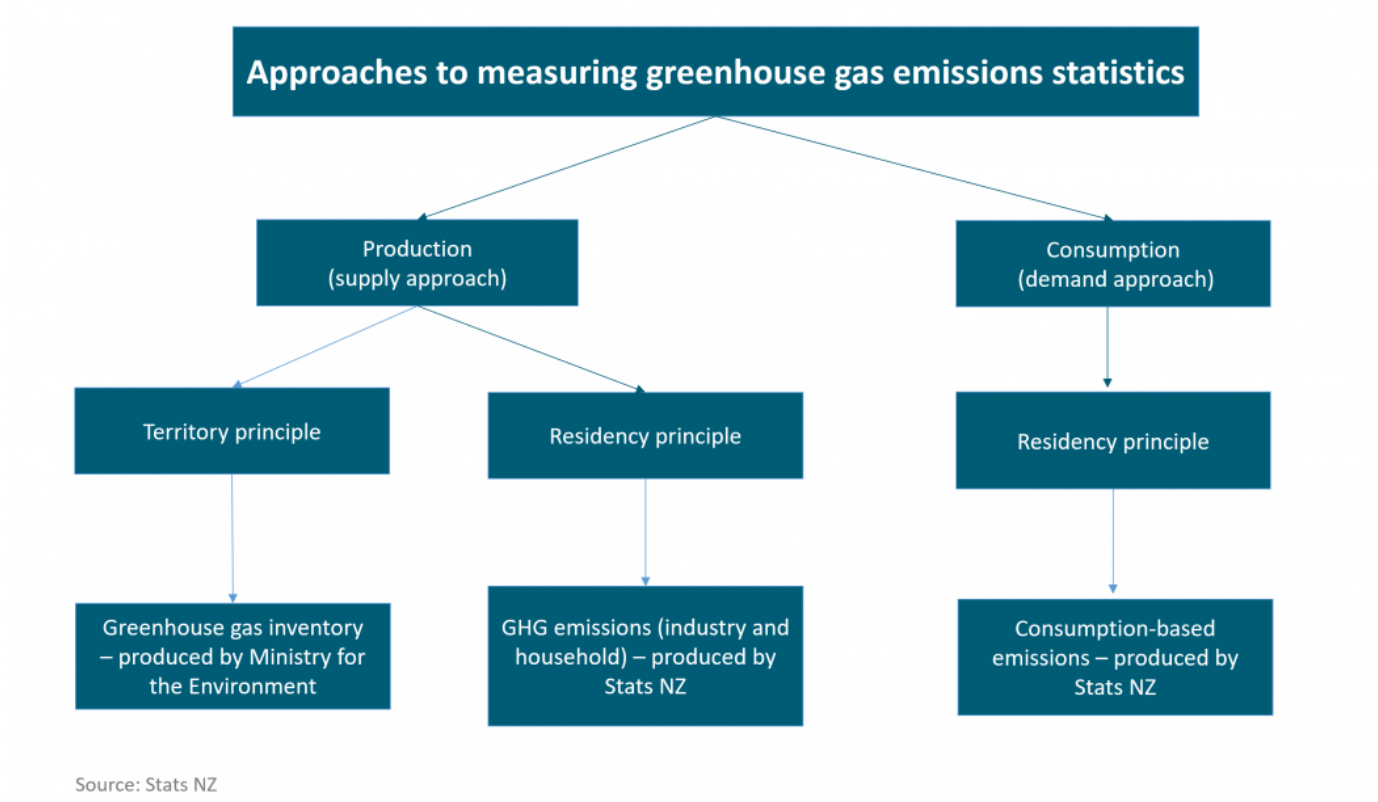
New Zealand's current greenhouse gas emissions statistics are:

- greenhouse gas inventory (GHG inventory) – emissions and removals on the territory (produced by Ministry for the Environment (MfE))
- greenhouse gases by industries and households (emissions account) – emissions on a production basis by economic residents (Stats NZ)
- consumption-based emissions – emissions embodied in goods and services consumed by economic residents (Stats NZ).

It is common for countries to report on emissions in these three ways (Department of Energy and Climate Change, 2015; European Environment Agency, 2013). However, countries use only the GHG inventory to report against greenhouse gas emissions reduction targets.

For more information on the data and methods Stats NZ uses to estimate emissions by industries and households and on a consumption-basis, see Environmental-economic accounts: Sources and methods (methods/environmental-economic-accounts-sources-and-methods) . For emissions and removals data produced by the Ministry for the Environment, see New Zealand's greenhouse gas inventory (https://www.mfe.govt.nz/publications/climate-change/new-zealands-greenhouse-gas-inventory-1990-2018) .

Figure 1



Text alternative for figure 1, Approaches to measuring greenhouse gas emissions statistics (methods/approaches-to-measuring-new-zealands-greenhouse-gas-emissions#fig-1) .

GHG inventory

The GHG inventory is based on the territory principle. It is best suited for understanding New Zealand's greenhouse gas profile (in both gross and net terms) and identifying the source processes that generate emissions within the territory.

Gross emissions are New Zealand's total emissions from the sectors of agriculture, energy, industrial processes and product use (IPPU), and waste, as well as gross emissions from Tokelau.

Net emissions are gross emissions combined with emissions and removals from the land use, land use change, and forestry (LULUCF) sector. The GHG inventory is the official annual estimate of all human-generated greenhouse gas emissions and removals in New Zealand, and is used for international reporting and reporting progress against targets (MfE, nd).

Emissions account

The emissions account (greenhouse gases by industries and households) is based on the residence of the emitter. It reconfigures inventory data to provide information on 'who' within the economy is emitting, and is designed to understand the economic and social context of emissions.

The account emphasises that an economic unit may emit from multiple processes. It distinguishes households from industries, and New Zealand residents from non-residents. The account covers only gross emissions from New Zealand's agriculture, energy, IPPU, and waste sectors.

A key feature of the emissions account is its use of a standard industrial classification. This facilitates the integration of emissions data with economic, population, or other environmental-economic statistics. Using industry classifications recategorises inventory data while the application of the residency principle leads to differences in total estimates.

() Production and consumption approaches to measuring emissions

In broad terms, emissions can be measured using either a production approach or a consumption approach.

The production approach focuses on the flow of gases at the point they pass from either human activity or economic activity to the environment. It is often referred to as a 'supply-side' approach. The production approach has two variations – the territory-based approach and the residency-based approach.

The consumption approach is often referred to as a 'demand-side' approach because it focuses on the use of goods and services and the emissions embodied in their production process.

Greenhouse gas emissions statistics are produced using different approaches to meet different demands and applications, and to capture the breadth of factors driving emissions. A single approach will not adequately capture all emissions-related questions and perspectives, hence the need for different approaches.

Below are New Zealand's current greenhouse gas emissions statistics.

- Greenhouse gas inventory, produced by MfE, is the official annual estimate of all human-generated greenhouse gas emissions and removals in New Zealand. It is prepared according to United Nations Framework Convention on Climate Change (UNFCCC) guidelines using Intergovernmental Panel on Climate Change (IPCC) 2006 methodologies. MfE compiles the greenhouse gas inventory using the production approach (territory principle). From this point, we refer to greenhouse gas inventory as either the 'GHG inventory' or the 'inventory'.
- Greenhouse gas emissions by industries and households, produced by Stats NZ, is based on the United Nations System of Environmental-Economic Accounting (SEEA) framework. Stats NZ compiles these statistics using the production approach (residency principle). From this point, we refer to this as the 'emissions account'.

- Consumption-based emissions are produced by Stats NZ as an extension of the SEEA framework using the residency principle.

It is common for countries to report on emissions in these three ways (Department of Energy & Climate Change, 2015; European Environment Agency, 2013). However, countries use only the GHG inventory to report against greenhouse gas emissions reduction targets.

Overview of frameworks for measuring greenhouse gases

GHG inventory

New Zealand produces emissions statistics under the inventory approach for international reporting encompassing the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and, from 2023, the Paris Agreement. The GHG inventory produced by MfE measures all human-caused emissions and removals that occur within a geographic territory.

The GHG inventory is the official source of New Zealand's emissions and removals data and is reported annually to the UNFCCC. It is also the basis by which progress towards targets is determined. Data is available from 1990, in line with international reporting requirements. Emissions and removals projections are also produced and reported every two years.

From a statistical perspective, the inventory is 'stand alone', that is, it is not part of a broader suite of statistics, but it uses many data sources, such as the Ministry of Business, Innovation and Employment (MBIE), Ministry for Primary Industries (MPI), Environmental Protection Agency (EPA), Stats NZ, and businesses. Further detail on the data sources, methods, emissions factors used, and data quality can be found in the annual New Zealand's greenhouse gas inventory (https://www.mfe.govt.nz/climate-change/state-of-our-atmosphere-and-climate/new-zealands-greenhouse-gas-inventory) report.

Emissions account

The emissions accounting approach is based on the United Nations System of Environmental-Economic Accounting (SEEA) framework. It 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.

SEEA framework

The SEEA Central Framework was adopted by the United Nations Statistical Commission in 2012 as the international standard for measuring the interactions between the environment and the economy. 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 gross domestic product (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. The estimates of greenhouse gases by industries and households are therefore part of a broader framework of environmental-economic considerations. For example, emissions to air (such as particulate matter), energy, material use, water, or waste, can also be produced under the SEEA framework and integrated with the estimates of greenhouse gases by industry.

The SEEA is suited to analytical extensions as it is designed to be integrated with other statistics. This includes comparisons of industry output (or other economic data) and emissions, measurement of emissions intensity (emissions per unit of GDP), tracking emissions in relation to economic growth, and identifying relative or absolute decoupling.

Stats NZ's emissions accounts are released as Greenhouse gas emissions (industry and household), and are part of the air emissions accounts (https://seea.un.org/content/air-emissions-accounts) in the SEEA framework (United Nations, 2012). However, we do not call them 'air emissions accounts' because the framework used for an air emissions account includes all emissions to air (for example, particulate matter) and the Stats NZ account includes only emissions of greenhouse gases.

Energy-first or inventory-first approaches

Emissions accounts can be developed using either an energy-first or inventory-first approach (Eurostat, 2015). The energy-first approach uses energy statistics/balances as the starting point for compiling emissions accounts, while the inventory-first approach uses the inventory as the main input data source.

New Zealand's emissions accounts are based on an inventory-first approach given the significance of non-energy sources in its emissions profile. Emissions accounts therefore are subject to the same uncertainties in the inventory as well as additional uncertainties from the assumptions made to convert industry data to specific classes of industry.

Consumption-based emissions

The consumption approach provides estimates of a country's carbon footprint. It 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 produce that good or service for final use. The consumption approach is also estimated using the SEEA framework.

The consumption approach builds upon the residence-based emissions estimates. It seeks to measure the emissions ‘embodied’ in a good or service throughout the entire supply chain required to produce that good or service for final use, so it requires the final user (household, business, or government) to be identified. This requires a link between industry supply of products and final user to be established, which requires the use of the industry-based production estimates.

As with emissions accounts, the consumption-based emissions statistics are suited to analytical extensions as it is designed to be integrated with other statistics. This includes deriving estimates of consumption of emissions per capita or in relation to expenditure and investment.

Unlike the production approaches, there are no international standards for measuring emissions on a consumption basis or reporting requirements. Eurostat provides methodological guidance and tools for countries to produce consumption estimates consistent with the SEEA framework (Eurostat, 2011; Eurostat, 2017).

The quality of consumption-based emissions is dependent on the emissions accounts as the primary input data, additional assumptions regarding the structure of the economy over time, and emissions intensities of industries in other countries.

Accounting for imports and exports

The consumption approach also identifies the emissions embodied in outputs produced by an industry that are exported (and thus not consumed domestically) and the emissions embodied in imports.

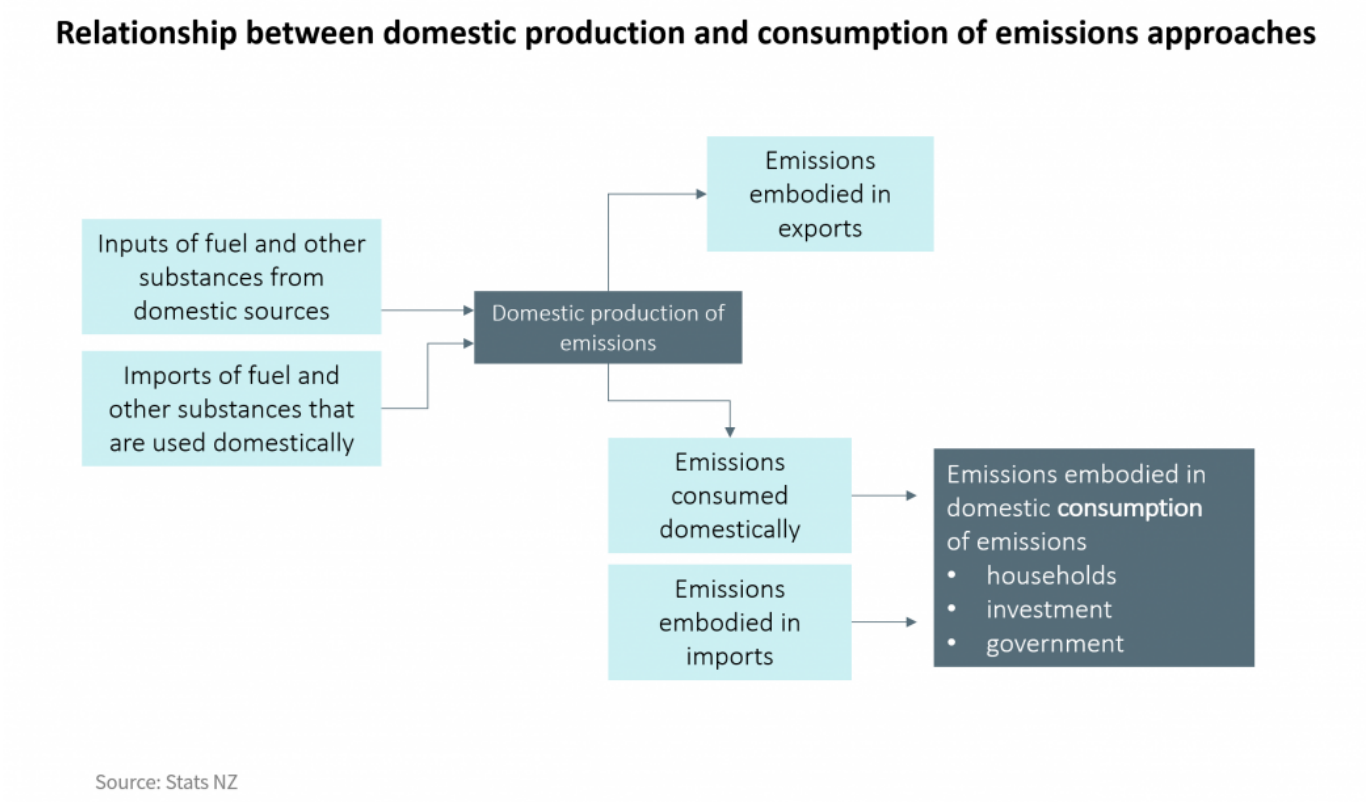
The consumption approach can show significantly different estimates (in terms of levels and trends) to emissions accounts depending on the role of trade and the types of products imported and exported.

While the emissions accounts show New Zealand produces a significant amount of emissions from dairy manufacturing, the consumption approach highlights that these emissions are embodied in exports. Embodied emissions from New Zealand’s imports of manufactured goods are not recorded in the inventory or the emissions account, but are in the consumption approach. Both approaches include the emissions from fuel used for driving cars in New Zealand.

Figure 2 shows how consumption-based emissions can be accounted for after factoring in the role of emissions embodied in exports and imports to emissions produced and consumed

domestically.

Figure 2



Text alternative for figure 2, Relationship between domestic production and consumption of emissions approaches (methods/approaches-to-measuring-new-zealands-greenhouse-gas-emissions#fig-2) .

() Understanding the differences in approaches

The production and consumption approaches to measuring emissions both offer important insights into the factors contributing to New Zealand's emissions. Understanding the statistical basis for how each approach is compiled is important for interpreting the estimates and for analytical applications. This includes identifying the scope, the means by which emissions are attributed to a source or unit, and the appropriate classifications for each approach.

The information that follows is suitable for readers interested in more technical details behind the different approaches.

Table 1 summarises the key features of each measurement approach in relation to various aspects such as the main purpose, underlying accounting principle, classifications, recording of flows, and coverage of pollutants.

Table 1

Features of three approaches to measuring emissions

	GHG inventory	Accounts (production)	Accounts (consumption)
Purpose	Provides official estimates, used for international reporting and for tracking and targets	Enhancing comparability of emissions data to economic statistics (for example, emissions intensity and decoupling). International comparisons.	Accounting for final use, and role of trade in emissions. Carbon footprinting and analytical indicators.
Accounting principle	Territory	Residency	Residency
Classification	Source/sink categories	Industries and households	Final use categories
Recording of flows	Gross and net	Gross	Gross
Framework	Stand alone (UNFCCC and IPCC)	Part of broader suite of environmental-economic accounts that aligns to the System of National Accounts	Extension to environmental-economic accounts
Pollutants	Greenhouse gases	Greenhouse gases, ambient air pollutants	Greenhouse gases, ambient air pollutants
Carbon dioxide from biomass used for energy	Memo item; not included in totals as emissions already counted at forest harvest	Recorded as a separate substance	Recorded as a separate substance

Note: UNFCCC – United Nations Framework Convention on Climate Change; IPCC – Intergovernmental Panel on Climate Change

Source: Stats NZ

Scope: Gross and net emissions

The territory and residence perspectives differ in relation to the treatment of removals of emissions from the atmosphere (sequestration) and therefore whether they include gross or net emissions.

Recording GHG emissions under the SEEA is based on the national accounting supply-use framework. This approach records the generation and release of emissions from economic units and households to the environment as a transaction between a unit and the environment. In practice, data for each economic unit is not readily available, but industry-level data is (which contains groups of units that undertake similar activities), so allocations are made at the industry rather than unit level. In this framework, the sequestering of emissions does not accrue to an economic unit so there is no corresponding use to be recorded. As a result, the SEEA framework only records gross emissions. The GHG inventory, however, is not constructed in the same supply-

use framework so it can record both the generation and removals of emissions, that is, gross and net.

The land use, land use change, and forestry (LULUCF) sector of the inventory covers the emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change, and forestry activities. LULUCF includes the emissions that arise from the changes in carbon stocks in soils and vegetation as a result of these activities, in addition to other non-carbon dioxide emissions such as methane and nitrous oxide.

The LULUCF sector of the inventory is generally excluded from SEEA emissions accounts. Emissions in the LULUCF sector can be recorded in the emissions accounts if data is available to allocate to industry, but because of the challenges in aligning the LULUCF sector to industry, it is excluded from emissions account estimates (Eurostat, 2015). This also means LULUCF cannot be incorporated into consumption-based emissions.

Scope: Coverage of greenhouse gases and other emissions

The production and consumption statistics both include emissions of carbon dioxide, methane, and nitrous oxide. The production statistics include emissions of hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride separately, while these are combined in reporting consumption-based emissions.

The supply-use framing of the SEEA also means carbon dioxide emissions from burning biomass (that is, living or recently dead organic material) for energy purposes can be recorded, in principle, as a separate substance (however, they are not yet recorded in New Zealand's emissions accounts). This is different from the inventory where carbon dioxide emissions from biomass are excluded from the energy sector in order to avoid double counting. These emissions are instead reported in the LULUCF sector of the inventory.

The SEEA is a framework for recording a range of environmental-economic flows, so apart from greenhouse gases, the air emissions account can also include ambient air pollutants (for example, particulate matter). However, Stats NZ has yet to include ambient air pollutants in its air emissions accounts.

Scope: Territory and residence principles

The territory principle allocates emissions taking place within national territory and offshore areas over which the country has jurisdiction. The inventory is prepared using the territory principle so it covers New Zealand's geographic zone, and therefore the Chatham Islands, and includes

emissions from Tokelau. Hence, the territory principle allocates the emissions to the territory where the activity takes place.

An alternative to the territory principle is the residency principle. The SEEA emissions account and consumption emissions are based on the residency principle. The residency principle allocates the activity to where the unit (that is, operator) undertaking the activity is resident, even though that activity may happen in a region other than where they are resident. The emitting unit may be a business or household.

For example, if a New Zealand fishing vessel purchases fuel in New Zealand, the associated emissions would be recorded in both the inventory and emissions accounts. If a non-New Zealand vessel purchases fuel in New Zealand, then the associated emissions would only be recorded in the inventory. If a New Zealand vessel lands catch overseas and refuels to return to New Zealand, then the emissions associated with those purchases would be recorded in the emissions accounts but not in the inventory.

The rationale for the residency principle is to maintain consistency with the national accounts. For determining whether a unit is resident, it is assessed whether it has a ‘centre of economic interest’ in New Zealand.

A foreign-owned company may still have a centre of economic interest in New Zealand if it has made significant investment in fixed capital and provides employment. Banks are an example where ownership is foreign, but the operation of the bank is focused on providing services for New Zealand, and therefore contributes to the economy. Foreign-owned banks in New Zealand would therefore also contribute to emissions under both the inventory and emissions accounting approaches.

In contrast, cruise ships are an example of foreign-owned and operated units that undertake activities in New Zealand’s geographic zone but are not considered economic residents because their centre of economic interest is not in New Zealand.

To convert from the territory-based production emissions to residence-based emissions, estimates of emissions are required for residents operating overseas and non-residents on the territory. Non-resident emissions are deducted while residents operating overseas are added to inventory estimates to obtain SEEA estimates. These adjustments are made, where data permits, for fishing vessels, international shipping, international aviation, and land transport. Adjustments may also be required for geographic scope. Units in Tokelau have no centre of economic interest in New Zealand, so they are excluded from the emissions accounts.

As a remote island nation, the role of international aviation and shipping are important in maintaining New Zealand’s economic ties. While New Zealand does not have the ‘fuel hopping’

problem many European countries have (where residents of a country cross borders to purchase fuel if it is cheaper), significant emissions from non-residents on the territory using land transport need to be accounted for. International tourists using vehicles in New Zealand are deducted from the SEEA estimates as they are non-resident operators.

Consumption-based emissions are based on the residency principle (given the definition of final consumption). They include emissions produced overseas from non-resident producers (emissions embodied in imports) in order to determine consumption from residents. The consumption-based emissions estimates also record the emissions produced by resident economic units consumed by non-residents (emissions embodied in exports).

The consumption-based emissions estimates can be reconciled with the emissions account through the emissions associated with imports and exports. However, they cannot be directly compared with the GHG inventory given the application of the residency principle, and the classifications used.

The spatial dimension: measuring emissions at the regional scale

In principle, emissions can be measured at any spatial scale using either the inventory approach or emissions accounting approach, so long as a clear spatial boundary is defined. Canada for example, produces emissions on a provincial scale using the inventory approach while Sweden produces regional estimates on an emissions accounting basis.

Not all datasets used to compile the GHG inventory have a spatial dimension (for example, fuel use is only available at the national level), so regional estimates for New Zealand are compiled using the SEEA framework by apportioning the emissions accounts using datasets that can link industry or households to region.

Stats NZ produces emissions estimates for 15 regions (based on regional district boundaries, with Nelson and Tasman combined) using data on agricultural production, economic output, population, transport movements, and data from other sources.

As with the national estimates, the regional estimates focus on the production of emissions by all resident economic units and households of a region. It thereby uses the same accounting principles, such as attribution to the operator, residency, gross accounting, and same industry classification. These estimates are reconciled to the national emissions account.

For accounting coherency, indirect emissions (emissions that are a consequence of the activities of the reporting entity but occur at sources owned or controlled by another entity, such as purchased electricity) are excluded, as are direct emissions by non-economic resident units (for example, international tourists). These exclusions reflect the production approach to measuring regional emissions and enable comparisons with regional GDP. Stats NZ is exploring the possibility of measuring regional emissions on a consumption basis.

Across regions in a country, the territory and residence principles may either lead to the same allocation to a region or a different allocation. Emissions from the GHG inventory's agriculture, industrial processes and product use (IPPU), and waste sectors are largely from stationary sources, given the fixed nature of capital used in their generation. Emissions from these sectors measured under either a residence or territory approach may be broadly similar.

However, in the case of energy, where emissions can be from stationary or mobile sources, emissions measured using the residency principle or geographic/territorial principle may differ substantially. This is observable in the national estimates where total emissions are greater than those of the GHG inventory (which is based on the territory principle) because emissions by residents overseas are greater than non-residents on the territory. At a regional level, this situation may arise due to firms purchasing fuel in other regions, or fuel in a region being purchased by international tourists.

Significance of differences in approaches

Table 2 shows the difference between the GHG inventory estimate and emissions accounts estimate for 2018, after applying the residency principle and differences in geographic scope.

Table 2

Difference between GHG inventory and emissions account, 2018

Item	Carbon dioxide equivalents (kilotonnes)
GHG inventory total – excluding LULUCF	78,862
Less non-residents operating on domestic territory	-609
Plus residents operating overseas	3,106
Plus/minus other differences	-4
Equals SEEA greenhouse gas by industries and households, account total (emissions account estimate)	81,355

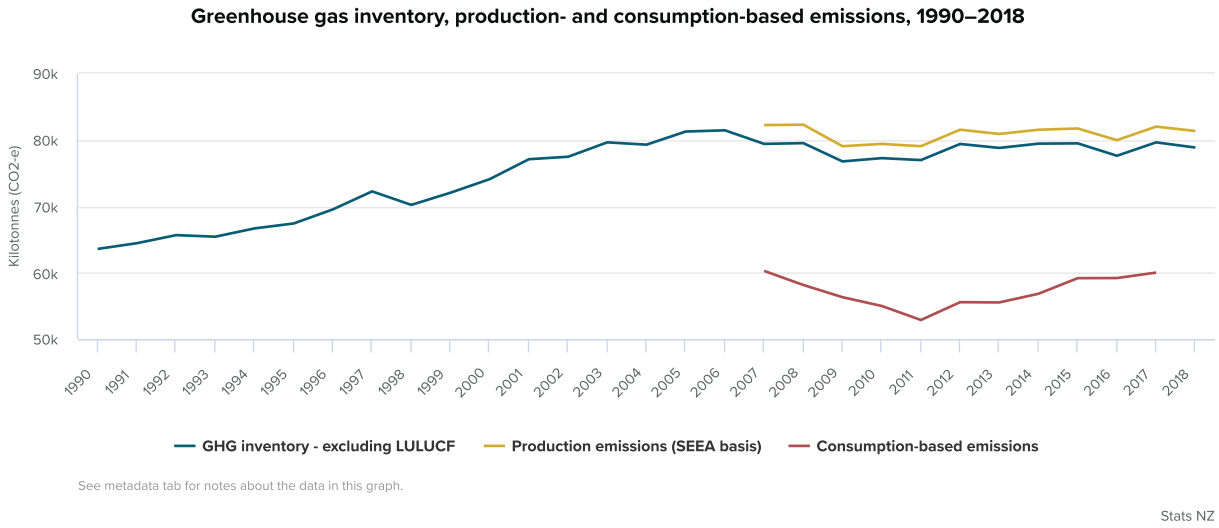
Note: LULUCF – land use, land use change, and forestry; SEEA – System of Environmental-Economic Accounting

Source: Stats NZ

Figure 3 shows that the emissions account has a similar trend to the gross emissions in the inventory. Emissions as measured under the SEEA were 3.2 percent (2,493 kilotonnes CO2-e) higher than those under the inventory in 2018. This is because emissions from New Zealand's activities overseas exceeded those by non-residents on domestic territory (residence adjustments).

Consumption-based emissions are lower than the emissions account as emissions embodied in exports exceed emissions embodied in imports across the time series.

Figure 3



Other differences between emissions under the GHG inventory approach and the SEEA approach are due to Tokelau's inclusion in the inventory, while the emissions accounts exclude it. The emissions accounting series begins in 2007, as the introduction of the Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006 affected the availability of input data by industry. Consumption-based emissions contain an additional lag due to the lack of national accounts information that covers the full 2018 year.

Attribution: Allocating emissions based on the source process, operator, and final user

A further distinction between the inventory and emissions accounting approaches is the notion of the operator. The emissions accounts allocate emissions to the operator, whereas the operator is not defined in the GHG inventory. The notion of the operator is also significant for distinguishing production from consumption.

As an example, consider an Air New Zealand flight from Auckland to Wellington with New Zealand residents and international tourists on board. The operator (that is, the unit that employs and controls the technology that generates the emission) is Air New Zealand. From both production perspectives, the flight is allocated to New Zealand because what is taken into consideration is the residence of the operator, not the passengers. That some of the passengers are international tourists is significant only from a consumption perspective, in which the share of emissions attributable to international tourists is counted as an export and the share from New Zealanders are included in the estimate of consumption-based emissions.

The distinction between operator and source process (in conjunction with the use of the territory or residence principle) has significant implications for measuring emissions as it drives the underlying classification used.

Classifications

With the residence principle comes a requirement to allocate emissions to a 'industry'. For consistency with economic statistics, units for estimating emissions by industry are allocated using a standard industrial classification. For New Zealand, this is the Australian New Zealand Standard Industrial Classification 2006 (http://aria.stats.govt.nz/aria/#ClassificationView:uri=http://stats.govt.nz/cms/ClassificationVersion/CAF (ANZSIC).

The territorial approach does not require a standard industrial classification. Instead, it focuses on the processes generating emissions, and groups emissions by the following categories:

- energy
- industrial processes and product use (IPPU)
- agriculture
- land use, land-use change, and forestry (LULUCF)
- waste.

By contrast, the ANZSIC classification groups units according to the predominant economic activity of the operator and assumes all units within an industry convert inputs to outputs in the same way. Industrial groups used in the emissions accounts include:

- agriculture, forestry, fishing
- mining
- manufacturing
- electricity, gas, water, and waste services
- construction
- retail and wholesale trade
- telecommunications, financial, rental, professional, and administrative services
- government and defence
- health care and social assistance
- education and training
- arts, recreation, and other services.

Both classification systems are compiled at a more detailed level and aggregated up for data release. The emissions accounting estimates for New Zealand, for example, are available for 114 industries. See Ariā

(http://aria.stats.govt.nz/aria/#ClassificationView:uri=http://stats.govt.nz/cms/ClassificationVersion/CAF
for more information on the classifications used.

The difference in perspectives, and therefore classifications, means similar terms in both the inventory and emissions accounts have different interpretations. For example, the term ‘manufacturing industry’ in the GHG inventory reflects the energy component in the manufacturing industries only, while manufacturing in the emissions accounts includes other sectors (for example, industrial processes and product use) and source categories. ‘Road transport’ in the inventory includes all forms of road transport (cars, light and heavy duty trucks, buses, and motorcycles) used on the territory while the ‘road transport industry’ in the emissions accounts incudes road freight, bus, and taxi companies (with household use of cars allocated to households and other industries’ direct use of vehicles allocated to the relevant industry). Similarly, in the consumption-based emissions estimates, household transport emissions include indirect emissions (those from across the supply chain to produce fuel used in private vehicles and from purchases related to use of other modes) as well as direct emissions from household use of vehicles, which is therefore broader than ‘transport’ by households in the emissions account.

Economic classifications can give additional insight into data that is not readily visible in the inventory. Examples include retail or wholesale trade, government and defence, health care and social assistance, and education and training. These industries are included in the ‘commercial’ sector of the inventory but can be identified in the emissions accounts where additional information allows for them to be estimated.

The consumption-based emissions approach allocates emissions depending on the final user: households, business, or government. The consumption-based estimates are broken down to show the factors contributing to total consumption emissions. This includes a breakdown by final user and emissions embodied in the goods and services consumed by the final use category.

The concept of the final user stems from the national accounts, in which the uses of resources are described either as intermediate or final. Intermediate uses consist of goods and services that are consumed (‘used-up’ or transformed) in a production process within the economy and during the accounting period. Final uses comprise all other uses of goods and services , such as by households, government, or investment in physical assets.

In the consumption-based approach, emissions associated with all the production processes, transport, storage, and retailing are associated with getting a product to the final user. To reallocate these emissions to the final user, use is made of the conceptual framing of the national accounts, particularly input-output tables, where the domestic final users make up the components of a nation’s consumption-based emissions, which is equal to production after accounting for trade. The link between industry (defined using ANZSIC) and final user is central to this process.

Table 3 shows how applying both residency or territory principles and classifications are important for understanding the steps taken from the production estimates on a territory basis to those on a residence basis, to consumption.

Table 3

Formula for deriving consumption emissions from territorial production emissions

Item	Classification	Allocation principle
Net emissions	Process	Territory
Less LULUCF		
Equals gross emissions produced on the territory (GHG inventory – excluding LULUCF)	Process	Territory
Plus resident emissions overseas		
Less non-residents on the domestic territory		
Plus/minus other differences		
Equals production of emissions by residents	Economic (industry)	Residency
Less emissions embodied in exports		
Plus emissions embodied in imports		
Equals consumption of emissions by residents	Economic (final user)	Residency

Note: LULUCF – land use, land use change, and forestry

Source: Stats NZ

Tourism emissions

Tourism, unlike ‘conventional’ industries such as agriculture or manufacturing which are classified in accordance with the goods and services they produce, is defined by the characteristics of the customer demanding tourism products. As such, tourism cuts across standard industry definitions (that is, spans multiple industries). This means that tourism emissions are not readily available from either emissions inventories or accounts. However, emissions related to tourism activity can be estimated by using the Tourism Satellite Account framework (United Nations World Tourism Organisation, 2008), thereby giving a more complete picture of the tourism carbon footprint.

Linking the TSA and the SEEA: A technical note (United Nations World Tourism Organization, 2019) outlines how emissions accounts can be linked to the Tourism Satellite Account (TSA) to show the contribution of tourism to environmental outcomes and resource use. The SEEA and TSA share the same accounting principles and industry definitions which allow for the integration of the two frameworks.

The physical supply and use table for flows of emissions (as described in table 3.7 of the SEEA 2012 central framework (https://seea.un.org/sites/seea.un.org/files/seea_cf_final_en.pdf)) can be adapted to present information on the generation of emissions by tourism industries. The attribution of emissions to tourism assumes that the relationship between economic activity and emissions does not depend on whether the outputs are sold to tourists or residents. For example, a unit of emissions is generated in the same manner in the accommodation industry for an international tourist or a New Zealand resident (even if most of the output of accommodation is dependent on international tourists).

The link between the SEEA and TSA enables an estimate of the carbon tourism footprint of international visitors and domestic tourism on the territory to be developed. The bridging table for tourism emissions (see table 4) shows how the emissions from tourism on the territory can be derived from the SEEA estimate. The SEEA estimate can be used to compare the contribution of tourism with the economy and employment, while emissions from tourism on the territory can be compared to gross emissions in the GHG inventory. Tourism consumption emissions are available from the consumption-based emissions estimates. These are broader than the production estimates as they account for emissions embodied in imports and emissions across the supply chain.

The scope of emissions related to international aviation differs across production approaches and other perspectives on international tourism (for example, origin of visitor focus). The emissions account includes emissions from resident airlines but does not identify the residency of the passenger. The GHG inventory, on the other hand, only records fuel sales for international aviation (that is, departures). Neither approach fully captures emissions for international visitors arriving and departing New Zealand (see table 5).

Table 4

Bridging table for tourism emissions, carbon dioxide equivalents (kilotonnes), 2018

	Carbon dioxide equivalents (kilotonnes)
Emissions attributable to tourism (SEEA basis)	6,026
Less resident emissions attributable to tourism overseas	-2,838
Plus non-residents (international tourists) on the territory	609
Emissions attributable to tourism (territory basis)	3,796

Note: Figures may not sum due to rounding. SEEA – System of Environmental-Economic Accounting.

Source: Stats NZ

Table 5

Coverage of international aviation emissions under different approaches

Carrier	Passenger	Arrival	Departure
National	NZ passenger	SEEA	SEEA GHG inventory
	International passenger	SEEA International visitor focus	SEEA GHG inventory International visitor focus
International	NZ passenger		GHG inventory
	International passenger	International visitor focus	GHG inventory International visitor focus

Note: SEEA – System of Environmental-Economic Accounting

Source: Stats NZ

Alignment between GHG inventory sectors and economic classifications

For consistency with economic statistics, the emissions accounting approach and consumption-based emissions approach use the same principles, classifications, and concepts used in compiling the national accounts. In the national accounts, for recording economic production, units are allocated to an industry based on their primary activity. However, a unit may undertake secondary activities and involve multiple emissions-producing processes.

As such, the emissions profile of an industry consists of multiple sources stemming from either different source processes used for its main activity or the different processes used for its different activities.

For example, consider a farm that has sheep, poultry, deer, and beef cattle, and grows barley and wheat crops. This farm applies fertiliser, has a small farm fill, and has a tractor and other vehicles for transporting goods and undertaking its activities.

The GHG inventory allocates the emissions from livestock, fertiliser, and crops to the agricultural sector; the associated direct energy emissions to energy; and the farm-fill emissions to waste.

However, the SEEA approach allocates these emission sources to the same economic unit. If most of the outputs of the industry are from sheep and beef farming, then the emissions would be allocated to the sheep, beef cattle, and grain farming industry as defined under ANZSIC, despite the industry undertaking activities related to horticulture or deer, poultry, and other livestock farming. Table 6 shows an example of how sector-based data from the inventory are allocated across agricultural sub-industries.

Table 6

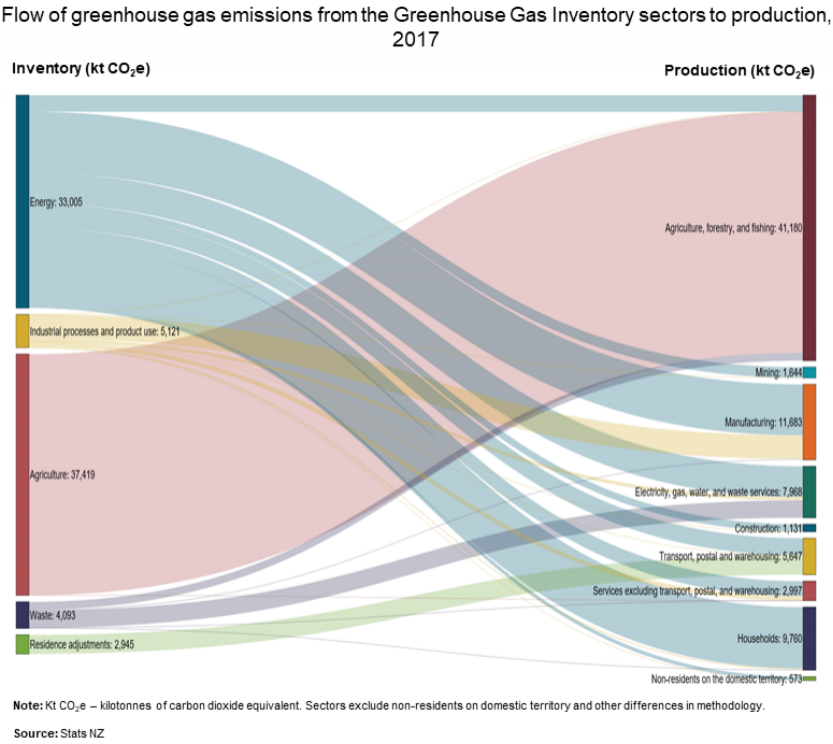
Process source emissions for agricultural industries, carbon dioxide equivalents (kilotonnes), 2018

Inventory sector	Production process	Industry				
		Horticulture	Sheep, beef cattle, and grain farming	Dairy cattle farming	Poultry, deer, and other livestock farming	Total
		Carbon dioxide equivalents (kilotonnes)				
Agriculture	Cropping	12.3	76.1	5.5	0.5	94.5
	Livestock and manure management	287.2	19,211.9	14,159.3	815.6	34,474.0
	Fertilisers	55.3	1,087.5	1,806.0	38.1	2,986.9
	Soils	0.3	17.7	11.3	0.8	30.0
Energy		452.8	422.4	399.0	77.3	1,351.5
Industrial processes and products use		0.8	1.3	1.4	0.3	3.7
Waste		189.9	702.4	278.3	14.3	1,184.9
Total emissions by industry		998.6	21,519.2	16,660.9	947.0	40,125.7
Note: Figures may not sum due to rounding. **Source**: Stats NZ						

Estimates of greenhouse gases from the inventory are allocated to industries for use in the emissions accounts in one of two ways. First, inventory emissions can be allocated directly to an industry. For example, emissions from public electricity (that is, grid electricity) and heat production are allocated to electricity, gas, water, and waste services. Second, inventory categories are allocated to multiple industries using additional data sources. This approach is used for road transport and for disaggregating high-level allocations (for example, commercial sector emissions to services excluding transport, postal, and warehousing) to lower-level industries (for example, retail or wholesale trade).

Figure 4 shows how sectors from the GHG inventory are allocated to an industry. It shows the relative contribution of both sectors and industries to total carbon dioxide equivalent emissions and that emissions from an industry can arise from several source categories. Energy emissions, for example, span activities throughout the economy.

Figure 4

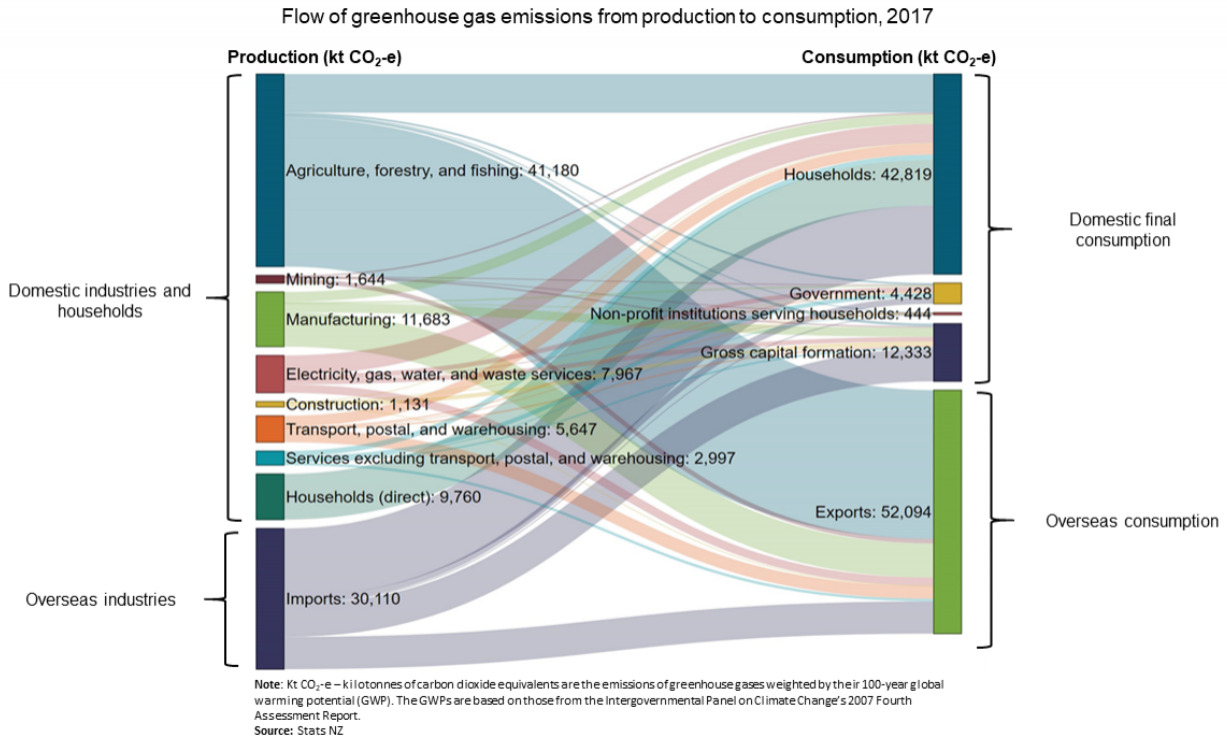


Text alternative for figure 4, Flow of greenhouse gas emissions from the greenhouse gas inventory sectors to production, 2017 (methods/approaches-to-measuring-new-zealands-greenhouse-gas-emissions#fig-4) .

The consumption-based emissions approach links emissions by industry and household to final user by using the statistical infrastructure of the national accounts. To show how emissions flow through the economy, into commodities, and to final use, the consumption-based emissions estimates use the input-output tables as their main data source along with residence-based emissions. Input-output tables describe the interactions between industries in an economy by showing the input requirements of industries to produce their outputs.

Figure 5 extends this analysis by showing emissions from production by industries and households to consumption. It shows that to estimate consumption, additional information on emissions embodied in imports is combined with emissions produced by New Zealand's industries and households. Domestic consumption-based emissions come mainly from households, followed by gross capital formation, government, and non-profit institutions serving households. Emissions embodied in exports are also shown on the consumption side as these are generated from domestic production and use of imports.

Figure 5



Text alternative for figure 5, Flow of greenhouse gas emissions from production to consumption, 2017 (methods/approaches-to-measuring-new-zealands-greenhouse-gas-emissions#fig-5) .

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Text alternatives

() Text alternative for figure 1, Approaches to measuring greenhouse gas emissions statistics

A flow diagram shows the two broad approaches to measuring emissions statistics. The production (supply approach) can be measured using the territory principle. The Ministry for the Environment uses the territory principle to produce the greenhouse gas inventory. Stats NZ also uses the territory principle to produce greenhouse gas emissions by industries and households. The second approach is the consumption (demand approach), which uses the residency principle and is produced by Stats NZ.

() Text alternative for figure 2, Relationship between domestic production and consumption of emissions approaches

A flow diagram shows the relationship between domestic production and consumption of emissions approaches. Domestic production of emissions depends on inputs to production and imports of fuel and other substances that are burnt domestically. Emissions from domestic production then go into emissions embodied in exports or emissions consumed domestically. Domestic consumption of emissions comes from emissions consumed domestically or imports of goods with embodied emissions. Domestic consumption of emissions can be allocated to households, investment, or government.

() Text alternative for figure 4, Flow of greenhouse gas emissions from the greenhouse gas inventory sectors to production, 2017

Image is of a Sankey chart, a type of flow diagram where the width of an arrow is proportional to the flow quantity. This chart shows how emissions from the greenhouse gas inventory sectors (left side of chart) align (flow) to industry emissions (right side) under the system of environmental-economic accounting (SEEA) production-based approach in 2018. The greenhouse gas inventory sectors are listed on the left: agriculture, energy, industrial processes and product use, and waste. Residence adjustments are shown below the greenhouse gas inventory sectors. Industries under SEEA approach are listed on the right: agriculture, forestry, and fishing; mining; manufacturing; electricity, gas, water, and waste services; construction; transport, postal, and warehousing; services excluding transport, postal, and warehousing.

() Text alternative for figure 5, Flow of greenhouse gas emissions from production to consumption, 2017

Image is of a Sankey chart, a type of flow diagram where the width of an arrow is proportional to the flow quantity. This chart shows how emissions from the production of goods and services (from the emissions production account) shown on the left side of chart, align (flow) to consumption emissions (emissions generated as a result of what we consume), on the right side. The industries that produce emissions are listed on the left: agriculture, forestry, and fishing; mining; manufacturing; electricity, gas, water, and waste services; construction; transport, postal, and warehousing; services excluding transport, postal, and warehousing. Households also produce emissions directly, for example, through cars burning fuel, and are also included on the production side. We also consume imports. Imports are included on the left as an input to consumption emissions. Final users/consumers of what we produce and import are listed on the right: households; government; non-profit institutions serving households, gross capital formation; and exports/foreign consumers.

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