Snapshot Municipal Carbon Emissions

Calculation Methods

Applies to:

- Emissions Reporting Tool version v0e
- Scaled Stationary Energy Tool version v0a
- Scaled Agriculture Tool version v0c
- Scaled Transport Tool version v0b

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Version table

Version	Author(s)	Date	Description of changes
V1a	Matt Sullivan-Kilgour	9/10/2019	First version of methodology
V1b	Matt Sullivan-Kilgour	20/2/2020	Updates for aviation methods
V2a	Matt Sullivan-Kilgour	18/08/2020	Updates for new commercial and industrial stationary energy methods, revised Agricultural methods, new wastewater method, new aviation data, new temporal scaling methods
V3a	Matt Sullivan-Kilgour and Rachel Armstead	15/09/2020	Updates for transport emissions and further aviation data
V3b	Matt Sullivan-Kilgour	27/04/2022	All data was updated where available. Updates to methods were made to: • Stationary energy (related to normalization to the Australian Energy Statistics data) • Stationary energy (related to improved subsector breakdowns of activity by industry) • Agriculture (adjustments to interpolation methods) • Transport (introduction of temporal scaling to Australian Energy Statistics in domestic aviation)

1. Overview of GHG Emissions Reported

This document outlines the methods employed for calculating emissions for municipalities as used by the Snapshot Climate emissions website. There are multiple objectives for these methods:

- They are compliant with the GPC Protocol for Cities, meaning that the outputs are compatible with international conventions such as the Global Covenant of Mayors for Climate and Energy
- They are consistent for municipalities across Australia, meaning that different towns and cities can compare, aggregate, and track emissions with other localities knowing that it is an apples-for-apples match.
- They 'sum to one', meaning that the individual municipal totals can be added together to equal the emissions for the whole country (only including the categories that are within the scope of these profiles).
- The methods only use data that is available for common usage, ensuring that others can duplicate the outcome of the approach, improving transparency and verification options.

1.1 Tiers of data

To improve understanding of the data that has been used for these methods, a tiering structure has been established based on the system used by the International Panel for Climate Change. When considering data, there are two primary categories to consider: activity data, and conversion factors. Activity data is a measurement of the activity that is generating emissions and is the primary mechanism for establishing emissions figures (the only alternative being to measure carbon emissions directly). Conversion factors are the variables that are used to convert this activity data into emissions estimates. This identifies three tiers:

Tier 1: Largely modelled data, with little or no local activity data available (these methods will take state, national, or international data, and scale them to the municipality using a relevant metric).

Tier 2: Local activity data, with conversion factors sourced from state, national, or international references.

Tier 3: Local activity data and locally sourced conversion factors, or actual activity-specific local carbon emissions data.

At present, most sectors of emissions that are included within snapshot are Tier 1.

1.2 Included categories

There are several categories of emissions that are not included in these methods. There are various reasons for not including these categories. In most instances, the emissions associated with these categories are included in another category. As this methods framework is developed, these categories will have individual methods developed.

Table 1: SE1 – Category tiers and inclusions

Category	Tier/Inclusion
Stationary Energy – Grid-Supplied Electricity	Tier 1
Stationary Energy – Gas	Tier 1
Stationary Energy – Fugitive Emissions	Not included
Stationary Energy – Additional Networked Energy	Not included
Transport – On Road	Tier 1
Transport – Aviation	Tier 2
Transport – Water	Not included
Transport – Off Road	Included in On Road
Transport – Trains	Included in On Road (for diesel) and Stationary Energy – Grid Supplied Electricity (for electric)
Transport – Buses	Included in On Road
Waste – Landfill	Tier 1
Waste – Other solid waste	Not included
Waste – Wastewater	Tier 1
Agriculture – Livestock	Tier 2
Agriculture – Crops	Tier 2
Agriculture – Rice Cultivation	Not included
Agriculture – Liming	Not included
Agriculture – Crop Residues	Not included
Agriculture – Urea Application	Not included
Land Use and Land Use Change – Cropland to Forestland	Tier 2
Land Use and Land Use Change – Grassland to Forestland	Tier 2
Land Use and Land Use Change – Forestland to Cropland	Tier 2
Land Use and Land Use Change – Bushfire	Not included
Industrial Processes and Product Use	Not included

1.3 Method naming conventions

Each of the methods named in this document employs a naming convention. This is done for the purpose of tracking methods over time, and for ensuring continuity with other work being done in this space. This continuity will enable future reports to be reconciled with previous reports without locking profiles into obsolete methods.

2. Stationary energy

Stationary energy relates to energy consumed at stationary locations, which largely means buildings. Stationary energy can take several forms, but the vast majority will be from grid-supplied electricity and grid-supplied natural gas.

2.1 SE1: Stationary Energy – Grid Supplied Electricity

Electricity consumption is estimated using the following method.

Table 2: SE1 - methods summary

Method	Data quality assessment			Key data requirement
	Data Quality	Activity data	Emissions factors	
SE1.5	Medium	Modelled activity data using robust assumptions	More general emission factors	Deriving municipal emissions from scaled state-level data

2.1.1 Method SE1.5: Modelled consumption data

This method uses municipal-level electricity consumption data from Ausgrid to create a linear regression model relating municipal electricity consumption with demographic and socio-economic characteristics sourced from the ABS.

Sources of data

- Ausgrid electricity consumption data for 32 LGAs in NSW, 2017 (SER10).
- Australian Bureau of Statistics

Description of method

The following steps are used to obtain an estimate for electricity usage for each sector:

Table 3: SE1.5 – Estimate of 2017 electricity usage

Sector	Estimation method
Residential	The regression *SE-REG6*[1] is used to obtain an estimate of residential electricity usage based on the municipality's population, number of households, population density (persons/km^2), SEIFA score and dwelling characteristics (% detached & semi-detached houses). This estimate is then adjusted using a state-based correction factor to account for the fact that the above regression equation was based on data from 32 municipalities from NSW. The correction factor for each state is the ratio of the estimated consumption for the state based on SE-REG6 to the actual consumption. This figure is then normalized against Australian Energy Statistics for Residential energy consumption, aggregated to the state level.
Commercial	The regression SE-REG7 is used to obtain an estimate of commercial electricity usage based on the municipality's number of commercial jobs, GRP and number of businesses.

[1] See appendix II for regressions

Sector	Estimation method
	This estimate is then adjusted using a state-based correction factor to account for the fact that the above regression equation was based on data from 32 municipalities from NSW. The correction factor for each state is the ratio of the estimated consumption for the state based on SE-REG7 to the actual consumption. This figure is then normalized against Australian Energy Statistics for Residential energy consumption, aggregated to the state level.
Industrial	Industrial emissions are derived from sectoral breakdowns in energy consumption from the Australian Energy Statistics. From this basis a regression is developed using SE-REG8 is used to obtain an estimate of industrial electricity usage based on the municipality's number of industrial jobs, GRP and number of businesses. This estimate is then adjusted using a state-based correction factor to account for the fact that the above regression equation was based on data from 32 municipalities from NSW. The correction factor for each state is the ratio of the estimated consumption for the state based on SE-REG7 to the actual consumption.

The data is then scaled temporally if needed to correlate to the inventory year. The scaling methods applied are:

Table 4: SE1.5 – Temporal scaling methods

Sector	Temporal scaling method
Residential	Firstly, scaled by population growth rate[2] for municipality. No further scaling is required because the Australian Energy Statistics are published annually.
Commercial	Firstly, scaled by commercial employment growth rate[3] for municipality. No further scaling is required because the Australian Energy Statistics are published annually.
Industrial	Firstly, scaled by commercial employment growth rate[4] for municipality. No additional scaling is required because the Australian Energy Statistics are published annually.

Conversion to carbon dioxide emissions

Once the activity data for the municipality is determined, emissions are determined by the following steps:

Table 5: SE1.5 – CO_2e emissions factors data source 1

Data description	Granularity	Source	Source ID[5]
Emissions factors for electricity	State-level	Department of Energy and Environment	GHG-R1

[2] See *population growth rate* calculations in Appendix I

[3] See *commercial employment growth rate* in Appendix I

[4] See *commercial employment growth rate* in Appendix I

[5] See appendix IV

Note: all electricity drawn from the grid across a state is considered to have the same emissions conversion factors regardless of where the municipality is located. Because of this there is no need to adjust the CO_2e conversion factors from the state-level figures.

Issues and considerations

- For the municipalities for which data is publicly available, please use SE1.6.
- The preliminary scaling to the municipal boundary is based on data from 32 municipalities in NSW. Although we have introduced a state-level scaling factor to account for differences between these and other states, it may not capture all differences between the areas.

2.1.2 Method SE1.6: Revised Industrial and Commercial Allocation

Profiles developed for reporting periods 2018 and onwards industrial stationary energy is calculated in the following way:

- Basic consumption of electricity and gas is drawn from table f of the Australian Energy Statistics. This is available by industrial subsector (a partial breakdown, not all subsectors are represented)
- Proportional representation of activity is done through cross referenced employment by LGA by place of work by occupation by industry subsector. These tables are derived from the ABS TableBuilder portal.
- The different categories between these two data sources are resolved through lookup tables. The details of these look up tables are outlined in Appendix IV.
- The different industrial subsectors are allocated to 'industrial-classified industry' and 'commercial-classified industry'. The classifications are detailed in Appendix IV.

The categorisation of employment for industrial classifications are:

Table 6: SE1.6: Industry Categories

Industry categories
Agriculture, Forestry and Fishing
Mining
Manufacturing
Electricity, Gas, Water and Waste Services
Construction
Wholesale Trade
Retail Trade
Accommodation and Food Services
Transport, Postal and Warehousing

Activity data is allocated to municipality as a proportion of the employment to the state total. For industrial-classified industry, the occupations used for classification are:

Table 7: SE1.6 Occupational Categories

Occupation categories

Technicians and Trades Workers
Labourers
Machinery Operators and Drivers

For commercial-classified industry, all occupation types are included.

Inter-year scaling

Inter-year scaling is accomplished through scaling for economic growth of GRP

2.2 SE2: Stationary Energy – Grid Supplied Gas

Gas consumption is estimated using the method outlined below. Note that this is only for networked (reticulated) Liquified Natural Gas (LNG). Bottle-supplied gas (LNG or LPG) is not estimated in this tool.

Table 8: SE2 Methods

Method	Data quality assessment			Key data requirement
	Data Quality	Activity data	Emissions factors	
SE2.5	Medium	Modelled activity data using robust assumptions	Specific emission factors	Modelled gas consumption data

2.2.1 Method SE2.5: Modelled consumption data

This method uses NSW Council data from Jemena to allocate gas consumption to the three sectors (residential, industrial, and commercial), and establishes regressions on industry job, number of businesses, and GRP.

Table 9: SE2.5 - Regression calculation method

Sector	Regression calculations method
Residential	Regressions are applied to the following municipal values: Gas availability – using concordances Population Households Density SEIFA (percentage) Dwelling structure = % detached The totals of the above, and an additional Constant are summed to generate the initial total consumption figure[6]. A state scaling factor is then applied to determine the proportion allocated to residential consumption. This is based on totals for NSW.

[6] See regressions calculations in Appendix II

Commercial	Regressions are applied to the following municipal values: No. businesses total No. man/mining businesses No. jobs GRP The totals of the above, and an additional Constant are summed to generate the initial total consumption figure[7]. Gas availability scaling is applied. A state level scaling factor is then applied to determine the proportion allocated to commercial consumption. This is based on totals for NSW.
Industrial	The following state level values for gas demand by sector are scaled by the municipal level percentage of employment by sector: Manufacturing Electricity generation Mining Transport and storage Other The totals of the above are summed to generate the initial total consumption figure. Gas availability scaling is applied.

Table 10: SE2.5 - Data sources for regressions

Data description	Granularity	Source	Source ID
Number of businesses	Municipal	Australian Bureau of Statistics 2018, Counts of Australian Businesses, including Entries and Exits, Jun 2013 to Jun 2017	BM-R4
Number of jobs	Municipal	2016 Census - Employment, Income and Education - LGA (POW) by OCCP - 1 Digit Level	BM-R5
GRP	Municipal	Australian Bureau of Statistics, Economic indicators by region	BM-R3
Gas consumption by sector	State	Electricity Gas Australia 2015	SE-R2

Temporal scaling

The data is then scaled temporally if needed to correlate to the inventory year. The scaling methods applied are:

Table 11: SE2.5 – Temporal scaling methods

Sector	Temporal scaling method

[7] See regressions calculations in Appendix II

Residential	Scaled by *population growth rate*[8] for municipality
Commercial	Scaled by *commercial employment growth rate*[9] for municipality
Industrial	Scaled by *industrial employment growth rate*[10] for municipality

Gas availability scaling

Gas is not available in all municipalities, and in many municipalities it is unevenly available. To accommodate this, gas scaling is done based on registered availability. For Eastern states, gas availability is listed by postcode. To calculate gas availability for a municipality, the following equation is used:

$$GA_m = \frac{\sum P_{pc} \cdot GA_{pc}}{\sum P_{pc}}$$

Where:

GA_m	=	Gas availability for municipality
GA_{pc}	=	Gas availability for post code (0 or 1)
P_{pc}	=	Proportion of postcode in municipality

To determine gas availability by postcode, various references were used depending on the relevant state. These references are identified below:

Table 12: SE2.5 – Gas availability data

Data description	Granularity	Source	Source ID
Gas availability - Victorian street/suburb combined listing	Street/postcode	Australian Gas Networks	SE-R5
Natural Gas Availability Queensland	Postcode	Australian Gas Networks	SE-R6
Natural Gas Availability South Australia	Postcode	Australian Gas Networks	SE-R8
Natural Gas Availability New South Wales	Postcode	Australian Gas Networks	SE-R9
Natural gas availability	Postcode	Jemena	SE-R13
Tas Gas Pipeline Locator	Street/postcode	Tas Gas Networks	SE-R14
WA gas pipeline network coverage maps	Street/postcode	ATCO	SE-R15
Natural Gas Availability Alice Springs	Postcode	Australian Gas Networks	SE-R16

[8] See *population growth rate* calculations in Appendix I

[9] See *commercial employment growth rate* in Appendix I

[10] See *industrial employment growth rate* in Appendix I

Data requirements

This method is fully modelled and requires no external data sourcing.

2.2.2 Method SE2.6: Revised Industrial and Commercial Allocation

Profiles developed for reporting periods 2018 and onwards industrial stationary energy is calculated in the following way:

- Basic consumption of electricity and gas is drawn from table f of the Australian Energy Statistics. This is available by industrial subsector (a partial breakdown, not all subsectors are represented)
- Proportional representation of activity is done through cross referenced employment by LGA by place of work by occupation by industry subsector. These tables are derived from the ABS Tablebuilder portal.
- The different categories between these two data sources are resolved through lookup tables. The details of these look up tables are outlined in Appendix IV.
- The different industrial subsectors are allocated to 'industrial-classified industry' and 'commercial-classified industry'. The classifications are detailed in Appendix IV.

The categorisation of employment for industrial classifications are:

Table 13: SE2.6: Industry Categories

Industry categories
Agriculture, Forestry and Fishing
Mining
Manufacturing
Electricity, Gas, Water and Waste Services
Construction
Wholesale Trade
Retail Trade
Accommodation and Food Services
Transport, Postal and Warehousing

Activity data is allocated to municipality as a proportion of the employment to the state total. For industrial-classified industry, the occupations used for classification are outlined in Table 14. For commercial-classified industry, all occupation types are included.

Table 14: SE2.6 Occupational Categories

Occupation categories
Technicians and Trades Workers
Labourers
Machinery Operators and Drivers

Inter-year scaling

Inter-year scaling is accomplished through scaling for economic growth of GRP.

3. Transport

Transport covers emissions associated with most forms of transport. Exclusions are consistent with those outlined in the GPC reporting format, such as transport within industrial facilities.

3.1 Overview of GHG Emissions Reported

This document outlines the methods employed for calculating emissions for municipalities as used by the Snapshot Climate emissions website. There are multiple objectives for these methods:

- They are compliant with the GPC Protocol for Cities, meaning that the outputs are compatible with international conventions such as the Global Covenant of Mayors for Climate and Energy
- They are consistent for municipalities across Australia, meaning that different towns and cities can compare, aggregate, and track emissions with other localities knowing that it is an apples-for-apples match.
- They 'sum to one', meaning that the individual municipal totals can be added together to equal the emissions for the whole country (only including the categories that are within the scope of these profiles).
- The methods only use data that is available for common usage, ensuring that others can duplicate the outcome of the approach, improving transparency and verification options.

3.1.1 Tiers of data

To improve understanding of the data that has been used for these methods, a tiering structure has been established based on the system used by the International Panel for Climate Change. When considering data, there are two primary categories to consider: activity data, and conversion factors. Activity data is a measurement of the activity that is generating emissions and is the primary mechanism for establishing emissions figures (the only alternative being to measure carbon emissions directly). Conversion factors are the variables that are used to convert this activity data into emissions estimates. This identifies three tiers:

Tier 1: Largely modelled data, with little or no local activity data available (these methods will take state, national, or international data, and scale them to the municipality using a relevant metric).

Tier 2: Local activity data, with conversion factors sourced from state, national, or international references.

Tier 3: Local activity data and locally sourced conversion factors, or actual activity-specific local carbon emissions data.

At present, most sectors of emissions that are included within snapshot are Tier 1.

3.1.2 Included categories

There are several categories of emissions that are not included in these methods. There are various reasons for not including these categories. In most instances, the emissions associated with these categories are included in another category. As this methods framework is developed, these categories will have individual methods developed.

Table 15: – Category tiers and inclusions

Category	Tier/Inclusion
Transport – On Road Automobiles	Tier 2
Transport – Aviation	Tier 2
Transport – Buses	Tier 2
Transport – Motorcycles	Tier 2
Transport – Trains	Tier 2
Transport – Trams	Tier 2
Transport – Water	Not included
Transport – Off Road	Not included

3.1.3 Method naming conventions

Each of the methods named in this document employs a naming convention. This is done for the purpose of tracking methods over time, and for ensuring continuity with other work being done in this space. This continuity will enable future reports to be reconciled with previous reports without locking profiles into obsolete methods.

3.1.4 Vehicle-based emissions tracking

There is a key method that is employed by Snapshot for allocating emissions from transport to specific municipalities, which is vehicle-based emissions. This means that emissions allocations are according to the travel of the vehicles themselves, as opposed to passengers within the vehicles. To illustrate:

- Aviation emissions are allocated to the start and end locations for planes (i.e. airports). Note also that for ease of calculation and interpretation all aviation emissions for flights into/out of the municipality are assumed to be Scope 3).
- Passenger vehicle emissions are allocated by the territorial emissions method outlined in the GPC
- Train emissions are allocated to the movements of trains, rather than the movements of passengers.

This may differ from other types of allocation methodologies, which presents the possibilities of introducing discrepancies. However, the reasons we are using this approach can be summarized with the following reasons:

- Passenger-based allocations are very complex and difficult to track.
- There is a host of transport emissions sources that cannot be meaningfully allocated under a similar methodology (such as freight), without introducing very complex lifecycle-style accounting.

- Passenger-based allocation methods creates unusual incentivisation structures that may run counter to the desired objectives of emissions reductions programs

3.2 TR1: On Road Transport – Modelled Data

3.2.1 Method TR1.2: On road transport fuels by vehicle & fuel type

A spatial scaling factor is developed using vehicle registration data by vehicle type, from the state to the municipal level. Each vehicle type is assigned a fuel type. State fuel sales data for diesel, petrol and LPG is then allocated to the appropriate vehicle type and scaled to the municipal level using the spatial scaling factor.

Petrol vehicles are assigned to the residential subsector whilst diesel and LPG vehicles are assigned to the commercial sector.

If required, the data is scaled temporally to align with the profile year. Residential fuel consumption is scaled temporally using regressions developed from municipal-level population data. Commercial fuel consumption is scaled temporally using regressions developed from municipal-level jobs data.

National-level emissions factors are applied.

This method uses the following data:

- fuel consumption by volume, state and vehicle type
- vehicles registered by municipality, year and vehicle type

Table 16: TR1.1 – Base data source

Data description	Granularity	Source	Source ID
Fuel sales data	State level	ABARES	TR-R1

User data requirements

None

Description of method

State-level data is scaled using relevant factors to represent municipal level fuel consumption figures.

The data is then scaled temporally if needed to correlate to the inventory year. The scaling methods applied are:

Petrol:	Scaled by population growth
Diesel:	Scaled by GRP growth
LPG/Dual/Other:	Scaled by GRP growth

Emissions are determined by the following steps:

- Carbon dioxide equivalent emissions are determined through the use of the figures published by the Australian federal government – National Greenhouse Accounting Factors
- These figures are provided for average gas emissions associated with consumption of each of the different fuel types

NSW Data

Because of the amalgamations that have taken place in NSW, some of the data that is used for estimating transport emissions needed alternative sources.

Table 17: TR1.1a – Base data source for NSW

Data description	Granularity	Source	Source ID
Fuel sales data	State level	NSW Roads and Maritime Services	TR-R

3.3 TR1: On Road Transport – Google EIE Data

3.3.1 Method TR1.3: On road automobile transport fuels by km travelled

This method utilizes Google transport activity data aggregated to the municipal boundary, and then applies a series of functions to convert this to estimated emissions. The activity data represents kilometers traveled for trips that begin, end, or are wholly within the municipal boundary (Scope 1). Additionally, for trips that travel outside of the municipal boundary 50% of these emissions are included (Scope 3). This method set is identified as 'City-induced activity' by the GPC (see diagram below):

Method	Allocation principle	Scope 1	Scope 2	Scope 3
Fuel Sales Approach	Not applicable unless additional steps taken	All emission from fuel sold within boundary	Any electric charging station in the city boundary	Not applicable unless fuel sales allocated between scope 1 and 3 by specified method
City-induced Activity (e.g. US demand models)	Origin-Destination	In-boundary trips and in-boundary portion of 50% of transboundary trips (pass-through trips excluded)		Out-of-boundary portion of 50% of transboundary trip
		In-boundary trips and in-boundary portion of all departing transboundary trips (pass-through trips excluded)		Out-of-boundary portion of all departing transboundary trips
Geographic/ Territorial (e.g., European demand models)	Not applicable	All traffic occurring within city boundaries, regardless of origin or destination		Not applicable unless additional steps taken
Resident Activity	Options	Either resident activity is all scope 1, or use origin-destination		N/A or origin-destination used

Figure 1: On road transport emissions accounting methods

The base data for undertaking this calculation is sourced from the Google EIE dataset, see table below.

Table 18: TR1.2 – Base data source

Data description	Granularity	Source	Source ID
Activity data by mode	Municipal level	Google EIE	TR-R10

User data requirements

None

Description of method

Local activity data is converted to emissions data by applying the conversion process shown in Figure 2Figure 1. This figure includes data sets that are used, shown with blue squares and identified by references R*XX*, and functions applied to the data, shown with orange diamonds and identified by references F*XX*.

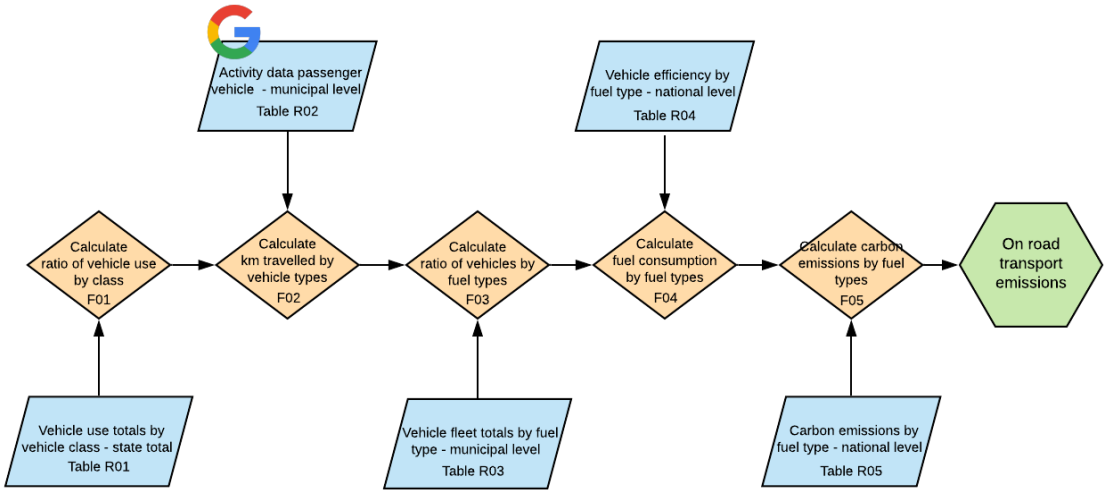

Figure 2: Calculation flowchart for on road transport emissions

Currently, no temporal scaling is applied as the base activity data is available for the desired inventory years. The references for the data are outlined in the section below.

The data tables used in the conversion flow chart are outlined below in Table 19.

Table 19: References for on road data

Ref	Name of Source Document	Location in Document	Author(s)	Date of Pub	URL
R01	9208.0 - Survey of Motor Vehicle Use, Australia, 12 months ended 30 June 2018	Table 14	Australian Bureau of Statistics	2019	https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/9208.012%20months%20ended%2030%20June%202018?OpenDocument
R02	Transport data	n/a	Google	2020	not available
R03	Vehicle type by Motive Power Code by LGA as at 31 December 2018	Table 1.1.13	Transport for NSW	2019	https://www.rms.nsw.gov.au/about/corporate-publications/statistics/registrationandlicensing/tables/table1113_2018q4.html
R04	9208.0 - Survey of Motor Vehicle Use, Australia, 12 months ended 30 June 2018	Table 4	Australian Bureau of Statistics	2019	https://www.abs.gov.au/AUSSTATS/abs@.nsf/mediareleasesbyReleaseDate/6006BF6A6CC2F525CA2574B20020D2AB?OpenDocument
R05	Australian National Greenhouse Accounts Factors 2019	Table 4	Australian Department of Environment and Energy	2019	https://publications.industry.gov.au/publications/climate-change/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-august-2019.html

The data used are outlined in the tables below.

Table 20: Data reference R01 - total km traveled by vehicle class

Motor vehicle use, by state/territory of registration by type of vehicle	Ref: R01
	Total kilometres travelled (millions km)
New South Wales	
Passenger vehicles	54,007
Light commercial vehicles	14,142
Rigid trucks	3,145
Articulated trucks	1,876
Non-freight carrying trucks	56
Total	**73,226**
Buses	634
Motor cycles	705

Table 21: Data reference R02 - activity data for on road transport (excerpt)

Activity data by mode			Ref:	R02
LGA	LGA Code	Mode	Travel Bounds	Distance
				km
Wollongong	18450	AUTOMOBILE	IN-BOUNDARY	646,223,529
Wollongong	18450	AUTOMOBILE	INBOUND	827,691,562
Wollongong	18450	AUTOMOBILE	OUTBOUND	819,566,064
Wollongong	18450	AUTOMOBILE	TOTAL	2,293,481,155

Table 22: Data reference R03 - vehicle count by motive code

Vehicle count by Motive Power Code by LGA							Ref:	R03
Vehicle class	Vehicle subclass	MOTIVE POWER CODE						
		Unleaded petrol	Leaded petrol	Diesel	LPG and petrol hybrids	Other fuel types	Unknown	No engine
Wollongong								
Light Vehicles	Passenger Vehicles	76875	1151	5291	701	450	250	0
	Off-road Vehicles	24680	34	10677	414	71	26	0
	People movers	1359	30	427	10	1	0	0
	Small Buses	212	8	329	10	0	3	0
	Mobile Homes	167	15	212	6	0	3	0
	Motor cycles	7028	235	3	1	5	26	0
	Scooters	282	13	0	0	0	1	0
	Light Trucks	5370	221	12527	537	28	41	0
	Light Plants	3	3	11	1	0	1	0
	Light Trailers	0	0	0	0	0	0	21477
	Other Vehicles	1	0	0	0	0	0	0
	TOTAL	115977	1711	29476	1681	554	350	21477
Heavy Vehicles	Buses	3	0	129	0	0	0	0
	Heavy Trucks	12	1	1990	1	9	4	0
	Prime Movers	0	0	447	0	0	0	0
	Heavy Plants	0	0	78	0	1	0	0
	Heavy Trailers	0	0	0	0	0	0	944
	TOTAL	15	1	2644	1	10	4	944
	Passenger vehicles	78613	1204	6259	727	451	256	0
	Light commercial vehicles	5370	221	12527	537	28	41	0

	Rigid trucks	12	1	1990	1	9	4	0
	Articulated trucks	0	0	447	0	0	0	0

Table 23: Data reference R04 - fuel efficiency by vehicle class

Fuel efficiency of vehicles			Ref:	R04
Vehicle type	Petrol	Diesel	LPG/CNG/dual fuel/hybrid and other	Total
	l/100 km	l/100 km	l/100 km	l/100 km
All years				
Passenger vehicles	10.7	11.5	11.8	10.8
Motorcycles	5.8	0	0	5.8
Light commercial vehicles	12.8	12.3	16.8	12.5
Rigid trucks	20.9	28.7	19.4	28.6
Articulated trucks	0	55.2	0	55.2
Non-freight carrying trucks	14.5	21.3	0	21.3
Buses	20.4	29.1	29.9	28.4
Total	10.8	18.4	12.9	13.4

Table 24: Data reference R05 - emissions factors for transport fuels

Emissions from transport fuels				Ref:	R05
Transport equipment type	Fuel combusted	Energy content factor (GJ/kL unless otherwise indicated)	Emission factor kg CO2-e/GJ (relevant oxidation factors incorporated)		
			CO2	CH4	N2O
Post-2004 vehicles	Gasoline (other than for use as fuel in an aircraft)	34.2	67.4	0.02	0.2
	Diesel oil	38.6	69.9	0.01	0.6
	Liquefied petroleum gas	26.2	60.2	0.4	0.3
	Ethanol for use as fuel in an internal combustion engine	23.4	0	0.2	0.2

These data sets are then manipulated with the formulas outlined below.

Function F01

This function converts the total distances travelled by each vehicle class into a proportion of total travel by 'automobiles'. In this function, it is assumed that the following vehicle classes form part of the 'automobile' category:

- Passenger vehicles
- Light commercial vehicles
- Rigid trucks
- Articulated trucks

- Non-freight carrying trucks

For each of these classes, a ratio is established according to the following formula:

$$R_i = \frac{D_i}{\sum_1^n D}$$

Where:

R_i	=	Ratio for vehicle class i
D_i	=	State distance travelled by vehicle class i
n	=	Total number of vehicle classes

Function F02

This function multiplies the distance travelled by the 'Automobile' category in the activity data set by the ratio of each vehicle class produced by function F01 to determine an estimate of the distance travelled by each vehicle class.

$$dist_i = dist_t \cdot R_i$$

Where:

$dist_i$	=	Municipal distance travelled by vehicle class i
$dist_t$	=	Total municipal distance travelled by 'automobiles'
R_i	=	Ratio of travel by vehicle class

Function F03

This function determines the composition of each vehicle class by fuel type and multiplies by the distance travelled to determine distance travelled by each vehicle class/fuel combination.

$$dist_{ij} = \frac{fleet_{ij}}{\sum fleet_i} \cdot dist_i$$

Where:

$dist_{ij}$	=	Municipal distance travelled vehicle class i and fuel type j
$fleet_{ij}$	=	Fleet size of vehicle class i and fuel type j
$fleet_i$	=	Fleet size of vehicle class i
$dist_i$	=	Municipal distance travelled by vehicle class i

Function F04

This function determines the amount of fuel consumed by each vehicle class and fuel type.

$$fuel_{ij} = \frac{dist_{ij}}{100} \cdot eff_{ij}$$

Where:

$fuel_{ij}$	=	amount of fuel consumed by vehicle class i in fuel j
$dist_{ij}$	=	Municipal distance travelled vehicle class i and fuel type j
eff_{ij}	=	Efficiency of vehicle class i in fuel type j (in litres/100km)

Function F05

This function converts fuel consumption by vehicle class and fuel type into carbon dioxide equivalent emissions.

$$emissions_{jg} = \sum_{i=0}^{m} e\_coeff_{jg} \cdot fuel_{ij}$$

Where:

$emissions_{jg}$	=	carbon emissions for greenhouse gas 'g' from fuel type j (in CO_2e)
e_coeff_{jg}	=	carbon emissions factor for greenhouse gas 'g' from fuel type j
fuelij	=	amount of fuel consumed by vehicle class i in fuel j
m	=	total number of vehicle classes

3.4 TR2: Aviation Travel

Aviation travel emissions are determined for passenger airplanes departing from or arriving into the municipality.

Table 25: TR2 - Methods

Method	Data quality			Key data requirement
	Data Quality	Activity data	Emissions factors	
TR2.1	High	Detailed Activity Data	Specific emission factors	Using national aviation data ascribed to airports
TR2.2	High	Detailed Activity Data	Specific emissions factors	Using regional aviation data ascribed to airports
TR2.3	Medium	Detailed Activity Data (excludes passenger activity)	Specific emissions factors	Using regional aviation data ascribed to airports

3.4.1 Method TR2.1: Emissions data for passenger aviation travel – Main Airports

This method scales emissions associated from passenger travel on the main commercial air carriers. For the 20 largest airports in Australia this data is aggregated through BITRE and includes passenger numbers, flight numbers, and starting and end destinations.

Exclusions

- Emissions are only determined for *domestic* flights
- Air freight in not currently included

This method uses the following data:

- Passenger activity by airport
- Emissions estimates per flight

Table 26: TR2.1 – Base data source

Data description	Granularity	Source	Source ID
Passenger activity data	Airport level	BITRE	TR-R2
Passenger activity data	Airport level	Transport Services NSW	TR-R7

User data requirements

None

Description of method

Airport level data is attributed to individual municipalities by the creation of a lookup table, as follows:

Table 27: TR2.1 – Airport lookup

Airport code	Name	State	LGA
ABX	Albury	NSW	Albury
ADL	Adelaide	SA	West Torrens
ARM	Armidale	NSW	Armidale Dumaresq
ASP	Alice Springs	NT	Alice Springs
AYQ	Ayers Rock	NT	Macdonnell
BDB	Bundaberg	Queensland	Bundaberg
BME	Broome	WA	Broome
BNE	Brisbane	Queensland	Brisbane
CBR	Canberra	ACT	ACT
CFS	Coffs Harbour	NSW	Coffs Harbour
CNS	Cairns	Queensland	Cairns
DBO	Dubbo	NSW	Dubbo
DPO	Devonport	Tasmania	Devonport
DRW	Darwin	NT	Darwin
GET	Geraldton	WA	Greater Geraldton
HBA	Hobart	Tasmania	Clarence
HTI	Hamilton Island	Queensland	Whitsunday
HVB	Hervey Bay	Queensland	Fraser Coast
KGI	Kalgoorlie	WA	Kalgoorlie-Boulder
KTA	Karratha	WA	Karratha
LST	Launceston	Tasmania	Northern Midlands
MCY	Sunshine Coast	Queensland	Sunshine Coast
MEL	Melbourne	Victoria	Hume
NTL	Newcastle	NSW	Port Stephens
OOL	Gold Coast	Queensland	Gold Coast
PER	Perth	WA	Belmont
PPP	Proserpine	Queensland	Whitsunday
PQQ	Port Macquarie	NSW	Port Macquarie-Hastings
QNA	Ballina	NSW	Ballina
SYD	Sydney	NSW	Bayside
PLO	Port Lincoln	SA	Lower Eyre Peninsula
EMD	Emerald	Queensland	Central Highlands
GLT	Gladstone	Queensland	Gladstone
ISA	Mount Isa	Queensland	Mount Isa
MKY	Mackay	Queensland	Mackay

Airport code	Name	State	LGA
MOV	Moranbah	Queensland	Isaac
ROK	Rockhampton	Queensland	Rockhampton
TSV	Townsville	Queensland	Townsville
MQL	Mildura	Victoria	Mildura
WNY	Burnie	Tasmania	Burnie
PHE	Port Hedland	WA	Port Hedland
ZNE	Newman	WA	East Pilbara
TMW	Tamworth	NSW	Tamworth Regional
WGA	Wagga Wagga	NSW	Wagga Wagga

Travel data is then calculated through the total transit between airports, with distances determined through the use of the ICAO calculator:

https://www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx

This lookup gives the following figures for travel and emissions (based on 2019 data):

Table 28: TR2.1 – Emissions and fuel use

Airport 1	Airport 2	Total trips	Average passenger	Aircraft fuel burn - kerosene (kg)	Total passengers CO2e/journey
ABX	SYD	6054	36	1,886	3,847
ADL	ASP	1201	106	11,652	24,536
ADL	BNE	6710	125	14,062	33,969
ADL	CBR	1715	103	9,676	17,773
ADL	MEL	19128	126	7,758	16,885
ADL	OOL	1481	142	14,324	35,498
ADL	PER	5465	112	16,909	35,825
ADL	PLO	7418	24	1,087	1,952
ADL	SYD	13931	134	11,312	27,043
ARM	SYD	4410	28	1,629	2,891
ASP	DRW	1766	68	11,170	20,134
ASP	MEL	0	0	15,683	20,087
ASP	SYD	0	0	16,668	21,349
AYQ	SYD	1391	136	17,963	42,634
BDB	BNE	3773	45	17,963	42,634
BME	PER	3673	87	13,056	29,089

Airport 1	Airport 2	Total trips	Average passenger	Aircraft fuel burn - kerosene (kg)	Total passengers CO2e/journey
BNE	CBR	6083	98	9,291	20,290
BNE	CNS	10168	133	13,188	31,620
BNE	DRW	3084	130	21,972	49,575
BNE	EMD	4049	44	4,431	7,976
BNE	GLT	5234	50	3,389	6,834
BNE	HBA	1424	147	15,486	39,593
BNE	HTI	1535	91	7,024	15,410
BNE	ISA	1835	66	12,482	22,211
BNE	MEL	25806	136	12,894	29,899
BNE	MKY	7202	92	7,228	14,903
BNE	MOV	0	0	3,937	6,578
BNE	NTL	6138	93	6,437	12,538
BNE	PER	5911	168	30,337	74,799
BNE	PPP	1805	145	9,574	24,178
BNE	ROK	7948	63	4,092	8,088
BNE	SYD	35401	133	8,611	19,650
BNE	TSV	8857	108	10,810	22,587
CBR	MEL	11330	99	5,505	10,550
CBR	SYD	16208	58	2,298	3,819
CFS	SYD	5086	66	3,672	7,072
CNS	MEL	5203	160	19,924	52,209
CNS	SYD	7321	150	17,068	43,195
CNS	TSV	4541	29	1,919	2,369
DBO	SYD	6174	30	1,488	2,771
DPO	MEL	0	0	2,557	5,157
DRW	MEL	2168	141	24,322	56,956
DRW	PER	1551	120	20,568	42,405
DRW	SYD	2570	123	23,576	50,233
GET	PER	2305	48	4,509	5,726
HBA	MEL	12161	130	7,774	17,032
HBA	SYD	4861	132	10,450	27,178
HTI	MEL	0	0	16,345	33,497
HTI	SYD	1784	122	13,522	31,943
HVB	SYD	0	0	10,007	12,817
KGI	PER	3436	70	5,950	9,692

Airport 1	Airport 2	Total trips	Average passenger	Aircraft fuel burn - kerosene (kg)	Total passengers CO2e/journey
KTA	PER	6170	70	10,517	18,494
LST	MEL	8921	103	5,084	11,271
LST	SYD	1940	146	9,721	24,896
MCY	MEL	3220	151	13,371	35,366
MCY	SYD	4380	134	9,059	23,455
MEL	MQL	4864	43	2,673	4,870
MEL	NTL	3378	140	9,189	22,809
MEL	OOL	12389	159	13,060	34,325
MEL	PER	11110	180	33,889	64,775
MEL	SYD	60059	151	9,026	21,293
MEL	TSV	372	0	17,713	37,403
MEL	WNY	0	0	1,261	5,500
NTL	OOL	0	0	6,670	14,273
OOL	SYD	18038	149	8,033	21,390
PER	PHE	4428	75	11,070	19,623
PER	SYD	9031	191	40,115	81,100
PER	ZNE	3957	71	9,536	14,992
PPP	SYD	324	143	13,968	35,615
PQQ	SYD	4376	43	1,690	3,490
QNA	SYD	3304	120	6,461	16,335
SYD	TMW	4538	39	1,832	3,147
SYD	TSV	1239	121	14,697	31,735
SYD	WGA	5502	33	1,708	3,412

Temporal scaling

The data is then scaled temporally if needed to correlate to the inventory year. The scaling methods applied are:

Table 29: TR2.1 – Temporal scaling methods

Sector	Temporal scaling method
Aviation emissions	Scaled by total fuel consumption in the Australian Energy Statistics.

3.4.2 Method TR2.1a: Emissions data for passenger aviation travel – Regional Airports

This method scales emissions associated with passenger travel from regional airports. These datasets are less comprehensive than those collected for the main airports and requires additional manipulation to be able to create emissions estimates. To date this information has only been collected for NSW councils.

Exclusions

- Emissions are only determined for *domestic* flights
- Air freight in not currently included

This method uses the following data:

- Destination of flights from airport
- Emissions estimates per flight

Table 30: TR2.2 – Base data source

Data description	Granularity	Source	Source ID
Flight emissions data	Flight level	ICAO	TR-R6
Passenger activity data	Airport level	Transport Services NSW	TR-R7
Flight destination data	Flight level	Flight Radar 24	TR-R8

User data requirements

None

Description of method

Airport level data is attributed to individual municipalities by the creation of a lookup table, as follows:

Table 31: TR2.2 – Airport municipality allocations

Airport	LGA	LGA Code
Albury	Albury	10050
Armidale	Armidale Regional	10130
Ballina	Ballina	10250
Bathurst	Bathurst Regional	10470
Broken Hill	Broken Hill	11250
Cobar	Cobar	11750
Coffs Harbour	Coffs Harbour	11800
Cooma		
Dubbo	Dubbo Regional	12390

Grafton	Clarence Valley	11730
Griffith	Griffith	13450
Lismore	Lismore	14850
Lord Howe Island	Offshore	
Merimbula	Bega Valley	10550
Moree	Moree Plains	15300
Moruya	Eurobodalla	12750
Mudgee	Mid-Western Regional	15270
Narrabri	Narrabri	15750
Narrandera	Narrandera	15800
Orange	Orange	16150
Parkes	Parkes	16200
Port Macquarie	Port Macquarie-Hastings	16380
Sydney	Sydney	17200
Tamworth	Tamworth Regional	17310
Taree	Mid-Coast	15240
Wagga Wagga	Wagga Wagga	17750
Williamtown	Newcastle	15900

For each of these airports, total passenger activities are available. To determine the amount of emissions to be applied the ratio of flight destinations are determined, and then emissions associated with each flight are developed. These proportions are then applied and summed, according to the following formula:

$$E_T = \sum_1^n E_f \cdot R_f \cdot F$$

Where:

E_T = Total emissions for airport

n = Number of flight destinations for airport

E_f = Emissions determined for a specific flight 'f' (starting and ending locations)

R_f = Ratio of flights for flight 'f' relative to total flights from airport

F = Total number of flights for airport

The amount of fuel consumed by an aircraft per flight was based on ICAO data and the following input assumptions.

- Weight of kerosene fuel (avtur) is 0.8kg/L
- Kerosene energy is 36.8GJ/kL
- Kerosene emissions is 69.82 kg CO_2e/GJ (69.6kg CO_2, 0.02 CH_4, 0.2 N_2O)

Temporal scaling

The data is then scaled temporally if needed to correlate to the inventory year. The scaling methods applied are:

Table 32: TR2.1a – Temporal scaling methods

Sector	Temporal scaling method
Regional aviation emissions	Scaled by total fuel consumption in the Australian Energy Statistics.

3.4.3 Method TR2.1b: Emissions data for passenger aviation travel – Minor Regional Airports

This method scales emissions associated with passenger travel from regional airports but excluding flight routes that have been accounted for in previous methods. It employs the same approach as method TR2.2 to calculating emissions associated with aircraft fuel consumption, but does not account for passenger activity by the airport due to insufficient information.

Exclusions

- Emissions are only determined for *domestic* flights
- Air freight is not currently included
- Passenger activity by airport

This method uses the following data:

- Destination of flights from airport
- Emissions estimates per flight

Table 33: TR2.3 – Base data source

Data description	Granularity	Source	Source ID
List of registered and certified airports	Municipality	CASA	TR-R9
Flight emissions data	Flight level	ICAO	TR-R6
Flight destination data	Flight level	Flight Radar 24	TR-R8

User data requirements

None

Description of method

Airport level data is attributed to individual municipalities by the creation of a lookup table, as follows:

Table 34: TR2.3 – Airport lookup

Code	Name	State	LGA
ABM	Northern Peninsula	QLD	Northern Peninsula Area
ABX	Albury	NSW	Albury
ADL	Adelaide	SA	West Torrens
ALH	Albany	WA	Albany
ARM	Armidale	NSW	Armidale Dumaresq
ASP	Alice Springs	NT	Alice Springs
AUU	Aurukun	QLD	Aurukun
AVV	Avalon	VIC	Greater Geelong
AYQ	Ayers Rock	NT	Macdonnell
BBL	Ballera	QLD	Bulloo
BCI	Barcaldine	QLD	Barcaldine
BDB	Bundaberg	QLD	Bundaberg
BDD	Badu Island	QLD	Torres Strait Island
BEU	Bedourie	QLD	Diamantina
BHQ	Broken Hill	NSW	Broken Hill
BHS	Bathurst	NSW	Bathurst Regional
BKQ	Blackall	QLD	Blackall Tambo
BME	Broome	WA	Broome
BNE	Brisbane	QLD	Brisbane
BNK/QNA	Ballina/Byron Gateway	NSW	Ballina
BQB	Busselton	WA	Busselton
BQL	Boulia	QLD	Boulia
BRK	Bourke	NSW	Bourke
BUC	Burketown	QLD	Burke
BVI	Birdsville	QLD	Diamantina
BWT	Wynyard	TAS	Waratah/Wynyard
BWU	Bankstown	NSW	Bankstown
BXG	Bendigo	VIC	Greater Bendigo
BYP	Barimunya	WA	East Pilbara
CAZ	Cobar	NSW	Cobar
CBR	Canberra	ACT	ACT
CED	Ceduna	SA	Ceduna
CFS	Coffs Harbour	NSW	Coffs Harbour
CJF	Coondewanna	WA	East Pilbara
CKW	Christmas Creek Mine Airport	WA	East Pilbara
CMA	Cunnamulla	QLD	Paroo
CNC	Coconut Island	QLD	Torres Strait Island
CNJ	Cloncurry	QLD	Cloncurry
CNS	Cairns	QLD	Cairns
CPD	Coober Pedy	SA	Coober Pedy
CTL	Charleville	QLD	Murweh

CTN	Cooktown	QLD	Cook
CUQ	Coen	QLD	Cook
CVQ	Carnarvon	WA	Carnarvon
DBO	Dubbo	NSW	Dubbo-Regional
DGE	Mudgee	NSW	Mid-Western Regional
DMD	Doomadgee	QLD	Doomadgee
DPO	Devonport	TAS	Devonport
DRW	Darwin	NT	Darwin
EDR	Pormpuraaw	QLD	Pormpuraaw
ELC	Elcho island	NT	East Arnhem
EMD	Emerald	QLD	Central Highlands
EPR	Esperance	WA	Esperance
FIZ	Fitzroy Crossing	WA	Derby-West Kimberley
FLS	Flinders Island	TAS	Flinders
GET	Geraldton	WA	Greater Geraldton
GFF	Griffith	NSW	Griffith
GFN	Grafton	NSW	Clarence Valley
GIC	Boigu Island	QLD	Torres Strait Island
GLT	Gladstone	QLD	Gladstone
GOV	Gove	NT	East Arnhem
GTE	Groote Eylandt	NT	-
GTS	The Granites	NT	Central Desert
GYL	Argyle	WA	Wyndham-East Kimberley
HBA	Hobart	TAS	Clarence
HCQ	Halls Creek	WA	Halls Creek
HGD	Hughenden	QLD	Flinders
HID	Horn Island	QLD	Torres
HTI	Hamilton Island	QLD	Whitsunday
HVB	Hervey Bay	QLD	Fraser Coast
IRG	Lockhart River	QLD	Lockhart River
ISA	Mount Isa	QLD	Mount Isa
IVR	Inverell	NSW	Inverell
JCK	Julia Creek	QLD	McKinlay
KGC	Kingscote	SA	Kangaroo Island
KGI	Kalgoorlie-Boulder	WA	Kalgoorlie-Boulder
KNS	King Island	TAS	King Island
KNX	Kununurra	WA	Wyndham-East Kimberley
KRB	Karumba	QLD	Carpentaria
KTA	Karratha	WA	Karratha
KTR	Katherine	NT	Katherine
KUG	Kubin	QLD	Torres Strait Island
KWM	Kowanyama	QLD	Kowanyama

LDH	Lord Howe Island	NSW	-
LEA	Learmonth	WA	Exmouth
LER	Leinster	WA	Leonora
LNO	Leonora	WA	Leonora
LRE	Longreach	QLD	Longreach
LST	Launceston	TAS	Northern Midlands
LSY	Lismore	NSW	Lismore
LVO	Laverton	WA	Laverton
MCV	McArthur River Mine	NT	Roper Gulf
MCY	Sunshine Coast	QLD	Sunshine Coast
MEB	Essendon Fields	VIC	Moonee Valley
MEL	Melbourne	VIC	Hume
MGB	Mount Gambier	SA	Grant
MGT	Milingimbi	NT	East Arnhem
MIM	Merimbula	NSW	Bega Valley
MJK	Shark Bay	WA	Shark Bay
MKR	Meekatharra	WA	Meekatharra
MKY	Mackay	QLD	Mackay
MMG	Mount Magnet	WA	Mount Magnet
MNG	Maningrida	NT	West Arnhem
MOO	Moomba	SA	-
MOV	Moranbah	QLD	Isaac
MQL	Mildura	VIC	Mildura
MRZ	Moree	NSW	Moree Plains
MYA	Moruya	NSW	Eurobodalla
NAA	Narrabri	NSW	Narrabri
NIF	Nifty	WA	East Pilbara
NRA	Narrandera	NSW	Narrandera
NTL	Newcastle	NSW	Port Stephens
NTN	Normanton	QLD	Carpentaria
OAG	Orange	NSW	Orange
OCM	Boolgeeda	WA	Ashburton
OKR	Yorke Island	QLD	Torres Strait Island
OLP	Olympic Dam	SA	Roxby Downs
ONG	Mornington Island	QLD	Mornington
ONS	Onslow	WA	Ashburton
OOL	Gold Coast	QLD	Gold Coast
OOM	Cooma - Snowy Mountains	NSW	Snowy Monaro Regional
PBO	Paraburdoo	WA	Ashburton
PER	Perth	WA	Belmont
PHE	Port Hedland	WA	Port Hedland
PHQ	The Monument	QLD	Cloncurry

PKE	Parkes	NSW	Parkes
PLO	Port Lincoln	SA	Lower Eyre Peninsula
PMK	Palm Island	QLD	Palm Island
PPP	Proserpine/Whitsunday Coast	QLD	Whitsunday
PQQ	Port Macquarie	NSW	Port Macquarie-Hastings
PUG	Port Augusta	SA	Port Augusta
RCM	Richmond (Qld)	QLD	Richmond
RMA	Roma	QLD	Maranoa
ROK	Rockhampton	QLD	Rockhampton
SBR	Saibai Island	QLD	Torres
SGO	Saint George	QLD	Balonne
SLJ	Solomon	WA	Ashburton
SYD	Sydney	NSW	Bayside
SYU	Warraber Island	QLD	Torres Strait Island
TCA	Tennant Creek	NT	Barkly
TEF	Telfer	WA	East Pilbara
TMW	Tamworth	NSW	Tamworth Regional
TQP	Trepell	QLD	McKinlay
TRO	Taree	NSW	Mid-Coast
TSV	Townsville	QLD	Townsville
UBB	Mabuiag Island	QLD	Torres Strait Island
ULP	Quilpie	QLD	Quilpie
WEI	Weipa	QLD	Cook
WGA	Wagga Wagga	NSW	Wagga Wagga
WGE	Walgett	NSW	Walgett
WIN	Winton	QLD	Winton
WLE	Miles	QLD	Western Downs
WLP	West Angelas	WA	East Pilbara
WME	Mount Keith	WA	Wiluna
WNR	Windorah	QLD	Barcoo
WOL	Shellharbour	NSW	Shellharbour
WTB	Brisbane West Wellcamp	QLD	Toowoomba
WUN	Wiluna	WA	Wiluna
WWI	Woodie Woodie	WA	East Pilbara
WYA	Whyalla	SA	Whyalla
XCH	Christmas Island	WA	-
XMY	Yam Island	QLD	Torres Strait Island
XTG	Thargomindah	QLD	Bulloo
ZBL	Biloela	QLD	Banana
ZNE	Newman	WA	East Pilbara

The data is then scaled temporally if needed to correlate to the inventory year. The scaling methods applied are:

Kerosene: Scaled by population growth

Due to insufficient data available, emissions could not be calculated for the following airports.

ICAO/IATA code	Name	State	LGA
YCPR	Cape Preston	WA	Karratha
YSCD	Carosue Dam	WA	Kalgoorlie-Boulder
YCPT	Carrapateena	SA	-
YCNY	Century Mine	QLD	Burke
YDLO	Darlot	WA	Leonora
YDGU	Degrussa	WA	Meekatharra
YDKG	Duketon Gold	WA	Laverton
YEJI	East Jaurdi	WA	Coolgardie
YFTA	Forrestania	WA	-
YGGE	Golden Grove	WA	Yalgoo
YGRS	Granny Smith	WA	Laverton
YGRM	Gruyere	WA	Laverton
YJAC	Jacinth Ambrosia	SA	-
YJUN	Jundee	WA	Wiluna
YNOV	Nova	WA	Dundas
YPLU	Plutonic	WA	Meekatharra
YWDC	Wodgina	WA	Karratha
YSRD	Sunrise Dam	WA	Laverton
YTBX	Thunderbox	WA	Leonora
YTRA	Tropicana	WA	Menzies
YBLT	Ballarat	VIC	Ballarat
YBLU	Bellevue	WA	Leonora
YBIR	Birchip	VIC	Buloke
YCUN	Cunderdin	WA	Cunderdin
YDOD	Donald	VIC	Buloke
YIVO	Ivanhoe	NSW	Central Darling
YIMB	Kimba	SA	Kimba
YLCG	Lake Cargelligo	NSW	Lachlan
YMNG	Mangalore	VIC	Strathbogie
YMUL	Murray Field	WA	Murray
YNHL	Nhill	VIC	Hindmarsh
YPCE	Pooncarie	NSW	Wentworth
YSTA	Saint Arnaud	VIC	Northern Grampians
YTTI	Troughton Island	WA	Wyndham-East Kimberley
YTBB	Tumby Bay	SA	Tumby Bay

YWBR	Warburton	WA	Ngaanyatjarraku
YWTO	Wentworth	NSW	Wentworth
YWHC	White Cliffs	NSW	Central Darling
YWYF	Wycheproof	VIC	Buloke
YYRM	Yarram	VIC	Wellington
YYWG	Yarrawonga	VIC	Moira
YGDA	Goodooga	NSW	Brewarrina
ABH	Alpha	QLD	Barcaldine
ACF	Archerfield	QLD	Brisbane
ARY	Ararat	VIC	Ararat
BLN	Benalla	VIC	Benalla
BQW	Balgo Hill	WA	Halls Creek
BRT	Bathurst Island	NT	Tiwi Islands
BSJ	Bairnsdale	VIC	East Gippsland
BUY	Bunbury	WA	Bunbury
BWB	Barrow Island	WA	Ashburton
BWQ	Brewarrina	NSW	Brewarrina
BZD	Balranald	NSW	Balranald
CBX	Condobolin	NSW	Lachlan
CCL	Chinchilla	QLD	Western Downs
CDU	Camden	NSW	Camden
CES	Cessnock	NSW	Cessnock
CKI	Croker Island	NT	West Arnhem
CLH	Coolah	NSW	Warrumbungle Shire
CMD	Cootamundra	NSW	Cootamundra
CML	Camooweal	QLD	Mount Isa
CMQ	Clermont	QLD	Isaac
CNB	Coonamble	NSW	Coonamble
COJ	Coonabarabran	NSW	Warrumbungle Shire
CVC	Cleve	SA	Cleve
CWT	Cowra	NSW	Cowra
CWW	Corowa	NSW	Federation
CXQ	Christmas Creek	WA	Derby-West Kimberley
CXT	Charters Towers	QLD	Charters Towers
CYG	Corryong	VIC	Towong
DGD	Dalgaranga Mine	WA	Mount Magnet
DNQ	Deniliquin	QLD	Deniliquin
DRB	Derby	WA	Derby-West Kimberley
DRN	Dirranbandi	QLD	Balonne
ECH	Echuca	VIC	Campaspe
FOS	Forrest	WA	Kalgoorlie-Boulder
FRB	Forbes	NSW	Forbes

GAH	Gayndah	QLD	North Burnett
GBL	South Goulburn Island	NT	West Arnhem
GBW	Ginbata	WA	East Pilbara
GLI	Glen Innes	NSW	Glen Innes Severn
GOO	Goondiwindi	QLD	Goondiwindi
GPD	Mount Gordon	QLD	Mount Isa
GPN	Garden Point (Pirlangimpi)	NT	Tiwi Islands
GTT	Georgetown	QLD	Etheridge
GUH	Gunnedah	NSW	Gunnedah
GUL	Goulburn	NSW	Goulburn Mulwaree
HLS	Saint Helens	TAS	Break O'Day
HLT	Hamilton	VIC	Southern Grampians
HSM	Horsham	VIC	Horsham
HTU	Hopetoun	VIC	Yarriambiack
HXX	Hay	NSW	Hay
IFL	Innisfail	QLD	Cassowary Coast
JAB	Jabiru	NT	West Arnhem
JAD	Jandakot	WA	Cockburn
KAX	Kalbarri	WA	Northampton
KBY	Streaky Bay	SA	Streaky Bay
KFE	Fortescue Dave Forrest	WA	East Pilbara
KFG	Kalkgurung	NT	Victoria Daly
KGY	Kingaroy	QLD	South Burnett
KNI	Katanning	WA	Katanning
KPS	Kempsey	NSW	Kempsey
KQR	Karara	WA	Perenjori
KRA	Kerang	VIC	Gannawarra
LEL	Lake Evella	NT	East Arnhem
LGH	Leigh Creek	SA	-
LHG	Lightning Ridge	NSW	Walgett
LLG	Chillagoe	QLD	Mareeba
MBW	Moorabbin	VIC	Kingston
MHU	Mount Hotham	VIC	Alpine
MJP	Manjimup	WA	Manjimup
MMM	Middlemount	QLD	Isaac
MRG	Mareeba	QLD	Mareeba
MTL	Maitland	NSW	Maitland
MWB	Morawa	WA	Morawa
NAC	Naracoorte	SA	Naracoorte and Lucindale
NGA	Young	NSW	Hilltops
NSO	Scone	NSW	Upper Hunter Shire
NUB	Numbulwar	NT	Roper Gulf

NYN	Nyngan	NSW	Bogan
OPI	Oenpelli	NT	West Arnhem
OSO	Osborne Mine	QLD	Burdekin
PAL	Parafield	SA	Salisbury
PKT	Port Keats	NT	West Daly
PPI	Port Pirie	SA	Port Pirie City and Dists
PTJ	Portland	VIC	Glenelg
PXH	Prominent Hill	SA	-
QRM	Narromine	NSW	Narromine
QRR	Warren	NSW	Warren
RAM	Ramingining	NT	East Arnhem
RBC	Robinvale	VIC	Swan Hill
RBS	Orbost	VIC	East Gippsland
RMK	Renmark	SA	Renmark Paringa
RPM	Ngukurr	NT	Roper Gulf
RTS	Rottnest Island	WA	Cockburn
RVT	Ravensthorpe	WA	Ravensthorpe
SHQ	Southport	QLD	Gold Coast
SHT	Shepparton	VIC	Greater Shepparton
SNB	Snake Bay (Milikapiti)	NT	Tiwi Islands
SNH	Stanthorpe	QLD	Southern Downs
SQC	Southern Cross	WA	Yilgarn
SRN	Strahan	TAS	West Coast
SWC	Stawell	VIC	Northern Grampians
SWH	Swan Hill	VIC	Swan Hill
SXE	West Sale	VIC	Wellington
TCW	Tocumwal	NSW	Berrigan
TDR	Theodore	QLD	Banana
TEM	Temora	NSW	Temora
TGN	Latrobe Valley	VIC	Latrobe
THG	Thangool	QLD	Banana
TTX	Truscott - Mungalalu	WA	Wyndham-East Kimberley
TUM	Tumut	NSW	Snowy Valleys
TWB	Toowoomba	QLD	Toowoomba
TYB	Tibooburra	NSW	-
UBU	Kalumburu	WA	Wyndham-East Kimberley
UIR	Quirindi	NSW	Liverpool Plains
WAZ	Warwick	QLD	Southern Downs
WGT	Wangaratta	VIC	Wangaratta
WIO	Wilcannia	NSW	Central Darling
WKB	Warracknabeal	VIC	Yarriambiack
WMB	Warrnambool	VIC	Warrnambool

WUD	Wudinna	SA	Wudinna
WUI	Murrin Murrin	WA	Laverton
WWY	West Wyalong	NSW	Bland
WYN	Wyndham	WA	Wyndham-East Kimberley
XMC	Mallacoota	VIC	East Gippsland
XTO	Taroom	QLD	Banana
ZBO	Bowen	QLD	Whitsunday

3.5 TR3: Bus Transport

3.5.1 Method TR3.1: Bus transport fuels by km travelled

This method utilizes Google transport activity data aggregated to the municipal boundary, and then applies a series of functions to convert this to estimated emissions.

Method	Allocation principle	Scope 1	Scope 2	Scope 3
Fuel Sales Approach	Not applicable unless additional steps taken	All emission from fuel sold within boundary	Any electric charging station in the city boundary	Not applicable unless fuel sales allocated between scope 1 and 3 by specified method
City-induced Activity (e.g. US demand models)	Origin-Destination	In-boundary trips and in-boundary portion of 50% of transboundary trips (pass-through trips excluded)		Out-of-boundary portion of 50% of transboundary trip
		In-boundary trips and in-boundary portion of all departing transboundary trips (pass-through trips excluded)		Out-of-boundary portion of all departing transboundary trips
Geographic/ Territorial (e.g., European demand models)	Not applicable	All traffic occurring within city boundaries, regardless of origin or destination		Not applicable unless additional steps taken
Resident Activity	Options	Either resident activity is all scope 1, or use origin-destination		N/A or origin-destination used

Figure 3: On road transport emissions accounting methods

The base data for undertaking this calculation is sourced from the Google EIE dataset, see table below.

Buses present an interesting challenge for reporting emissions according to the GPC protocol, because their movements are not necessarily correlated to trips that originating and/or ending within the municipal boundary. For this reason, the preferred method for determining emissions is the Geographic/territorial (as outlined in Figure 7). Scope 1 emissions are for travel wholly within the boundary. Scope 3 emissions are not considered for this activity area.

Table 35: TR1.2 – Base data source

Data description	Granularity	Source	Source ID
Activity data by mode	Municipal level	Google EIE	TR-R10

User data requirements

None

Description of method

Local activity data is converted to emissions data by applying the conversion process shown in Figure 2Figure 1. This figure includes data sets that are used, shown with blue squares and identified by references R*XX*, and functions applied to the data, shown with orange diamonds and identified by references F*XX*.

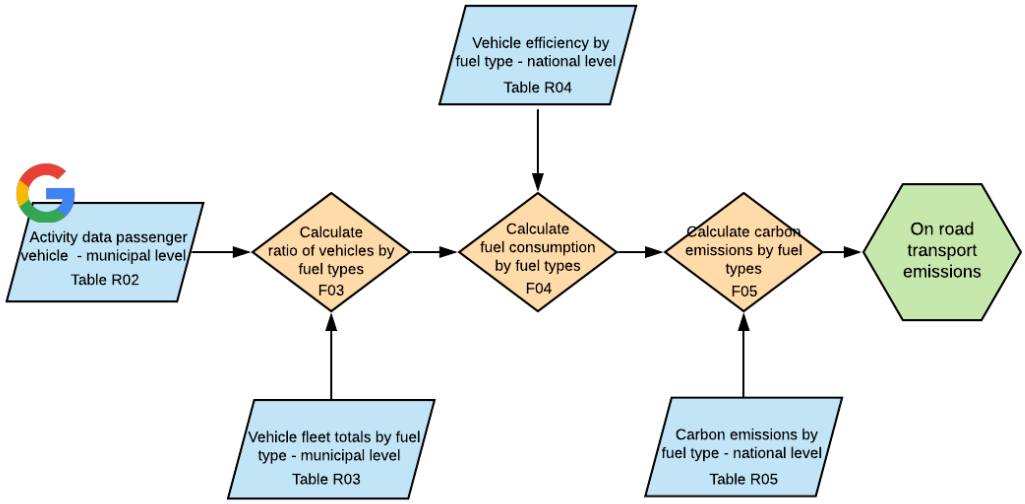

Figure 4: Calculation flowchart for on road transport emissions

Currently, no temporal scaling is applied as the base activity data is available for the desired inventory years. The references for the data are outlined in the section below.

The data tables used in the conversion flow chart are outlined below in

Table 19.

Table 36: References for on road data

Ref	Name of Source Document	Location in Document	Author(s)	Date of Pub	URL
R02	Transport data	n/a	Google	2020	not available
R03	Vehicle type by Motive Power Code by LGA as at 31 December 2018	Table 1.1.13	Transport for NSW	2019	https://www.rms.nsw.gov.au/about/corporate-publications/statistics/registrationandlicensing/tables/table1113_2018q4.html
R04	9208.0 - Survey of Motor Vehicle Use, Australia, 12 months ended 30 June 2018	Table 4	Australian Bureau of Statistics	2019	https://www.abs.gov.au/AUSSTATS/abs@.nsf/mediareleasesbyReleaseDate/6006BF6A6CC2F525CA2574B20020D2AB?OpenDocument
R05	Australian National Greenhouse Accounts Factors 2019	Table 4	Australian Department of Environment and Energy	2019	https://publications.industry.gov.au/publications/climate-change/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-

					greenhouse-accounts-factors-august-2019.html

The data used are outlined in the tables below.

Table 37: Data reference R02 - activity data for on road transport (excerpt)

Activity data by mode			**Ref:**	**R02**
LGA	LGA Code	Mode	Travel Bounds	Distance
				km
Wollongong	18450	STANDARD BUS	IN-BOUNDARY	7,765,417
Wollongong	18450	STANDARD BUS	TOTAL	7,765,417

Table 38: Data reference R03 - vehicle count by motive code

Vehicle count by Motive Power Code by LGA							**Ref:**	**R03**
Vehicle class	Vehicle subclass	MOTIVE POWER CODE						
		Unleaded petrol	Leaded petrol	Diesel	LPG and petrol hybrids	Other fuel types	Unknown	No engine
Wollongong								
Light Vehicles	Passenger Vehicles	76875	1151	5291	701	450	250	0
	Off-road Vehicles	24680	34	10677	414	71	26	0
	People movers	1359	30	427	10	1	0	0
	Small Buses	212	8	329	10	0	3	0
	Mobile Homes	167	15	212	6	0	3	0
	Motor cycles	7028	235	3	1	5	26	0
	Scooters	282	13	0	0	0	1	0
	Light Trucks	5370	221	12527	537	28	41	0
	Light Plants	3	3	11	1	0	1	0
	Light Trailers	0	0	0	0	0	0	21477
	Other Vehicles	1	0	0	0	0	0	0
	TOTAL	115977	1711	29476	1681	554	350	21477
Heavy Vehicles	Buses	3	0	129	0	0	0	0
	Heavy Trucks	12	1	1990	1	9	4	0
	Prime Movers	0	0	447	0	0	0	0
	Heavy Plants	0	0	78	0	1	0	0
	Heavy Trailers	0	0	0	0	0	0	944
	TOTAL	15	1	2644	1	10	4	944

Passenger vehicles	78613	1204	6259	727	451	256	0
Light commercial vehicles	5370	221	12527	537	28	41	0
Rigid trucks	12	1	1990	1	9	4	0
Articulated trucks	0	0	447	0	0	0	0

Table 39: Data reference R04 - fuel efficiency by vehicle class

Fuel efficiency of vehicles			**Ref:**	**R04**
Vehicle type	Petrol	Diesel	LPG/CNG/dual fuel/hybrid and other	Total
	l/100 km	l/100 km	l/100 km	l/100 km
All years				
Passenger vehicles	10.7	11.5	11.8	10.8
Motorcycles	5.8	0	0	5.8
Light commercial vehicles	12.8	12.3	16.8	12.5
Rigid trucks	20.9	28.7	19.4	28.6
Articulated trucks	0	55.2	0	55.2
Non-freight carrying trucks	14.5	21.3	0	21.3
Buses	20.4	29.1	29.9	28.4
Total	10.8	18.4	12.9	13.4

Table 40: Data reference R05 - emissions factors for transport fuels

Emissions from transport fuels				**Ref:**	**R05**
Transport equipment type	Fuel combusted	Energy content factor (GJ/kL unless otherwise indicated)	Emission factor kg CO2-e/GJ (relevant oxidation factors incorporated)		
			CO2	CH4	N2O
Post-2004 vehicles	Gasoline (other than for use as fuel in an aircraft)	34.2	67.4	0.02	0.2
	Diesel oil	38.6	69.9	0.01	0.6
	Liquefied petroleum gas	26.2	60.2	0.4	0.3
	Ethanol for use as fuel in an internal combustion engine	23.4	0	0.2	0.2

These data sets are then manipulated with the formulas outlined below.

Function F03

This function determines the composition of each vehicle class by fuel type and multiplies by the distance travelled to determine distance travelled by each vehicle class/fuel combination.

$$dist_{ij} = \frac{fleet_{ij}}{\sum fleet_i} \cdot dist_i$$

Where:

$dist_{ij}$ = Municipal distance travelled vehicle class i and fuel type j

$fleet_{ij}$ = Fleet size of vehicle class i and fuel type j

$fleet_i$ = Fleet size of vehicle class i

$dist_i$ = Municipal distance travelled by vehicle class i

Function F04

This function determines the amount of fuel consumed by each vehicle class and fuel type.

$$fuel_{ij} = \frac{dist_{ij}}{100} \cdot eff_{ij}$$

Where:

$fuel_{ij}$ = amount of fuel consumed by vehicle class i in fuel j

$dist_{ij}$ = Municipal distance travelled vehicle class i and fuel type j

eff_{ij} = Efficiency of vehicle class i in fuel type j (in litres/100km)

Function F05

This function converts fuel consumption by vehicle class and fuel type into carbon dioxide equivalent emissions.

$$emissions_{jg} = \sum_{i=0}^{m} e\_coeff_{jg} \cdot fuel_{ij}$$

Where:

$emissions_{jg}$ = carbon emissions for greenhouse gas 'g' from fuel type j (in CO_2e)

e_coeff_{jg} = carbon emissions factor for greenhouse gas 'g' from fuel type j

$fuel_{ij}$ = amount of fuel consumed by vehicle class i in fuel j

m = total number of vehicle classes

3.6 TR4: On Road Motorcycle Transport

3.6.1 Method TR4.1: Motorcycle transport fuels by km travelled

This method utilizes Google transport activity data aggregated to the municipal boundary, and then applies a series of functions to convert this to estimated emissions. The activity data represents kilometers traveled for trips that begin, end, or are wholly within the municipal boundary (Scope 1). Additionally, for trips that travel outside of the municipal boundary 50% of these emissions are included (Scope 3). This method set is identified as 'City-induced activity' by the GPC (see diagram below):

Method	Allocation principle	Scope 1	Scope 2	Scope 3
Fuel Sales Approach	Not applicable unless additional steps taken	All emission from fuel sold within boundary	Any electric charging station in the city boundary	Not applicable unless fuel sales allocated between scope 1 and 3 by specified method
City-induced Activity (e.g. US demand models)	Origin-Destination	In-boundary trips and in-boundary portion of 50% of transboundary trips (pass-through trips excluded)		Out-of-boundary portion of 50% of transboundary trip
		In-boundary trips and in-boundary portion of all departing transboundary trips (pass-through trips excluded)		Out-of-boundary portion of all departing transboundary trips
Geographic/ Territorial (e.g., European demand models)	Not applicable	All traffic occurring within city boundaries, regardless of origin or destination		Not applicable unless additional steps taken
Resident Activity	Options	Either resident activity is all scope 1, or use origin-destination		N/A or origin-destination used

Figure 5: On road transport emissions accounting methods

The base data for undertaking this calculation is sourced from the Google EIE dataset, see table below.

Table 41: TR1.2 – Base data source

Data description	Granularity	Source	Source ID
Activity data by mode	Municipal level	Google EIE	TR-R10

User data requirements

None

Description of method

Local activity data is converted to emissions data by applying the conversion process shown in Figure 2Figure 1. This figure includes data sets that are used, shown with blue squares and identified by references R*XX*, and functions applied to the data, shown with orange diamonds and identified by references F*XX*.

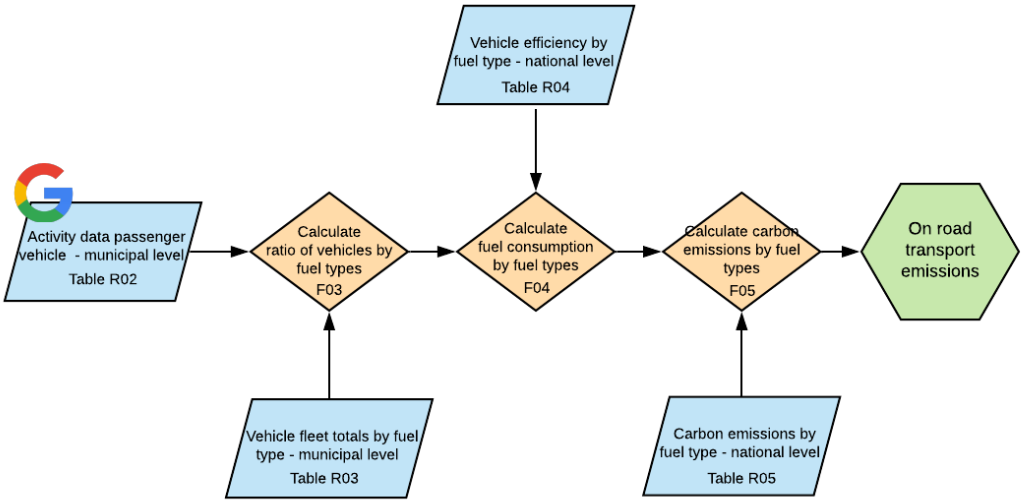

Figure 6: Calculation flowchart for motorcycle on road transport emissions

Currently, no temporal scaling is applied as the base activity data is available for the desired inventory years. The references for the data are outlined in the section below.

The data tables used in the conversion flow chart are outlined below in

Table 19.

Table 42: References for on road data

Ref	Name of Source Document	Location in Document	Author(s)	Date of Pub	URL
R02	Transport data	n/a	Google	2020	not available
R03	Vehicle type by Motive Power Code by LGA as at 31 December 2018	Table 1.1.13	Transport for NSW	2019	https://www.rms.nsw.gov.au/about/corporate-publications/statistics/registrationandlicensing/tables/table1113_2018q4.html
R04	9208.0 - Survey of Motor Vehicle Use, Australia, 12 months ended 30 June 2018	Table 4	Australian Bureau of Statistics	2019	https://www.abs.gov.au/AUSSTATS/abs@.nsf/mediareleasesbyReleaseDate/6006BF6A6CC2F525CA2574B20020D2AB?OpenDocument
R05	Australian National Greenhouse Accounts Factors 2019	Table 4	Australian Department of Environment and Energy	2019	https://publications.industry.gov.au/publications/climate-change/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-august-2019.html

The data used are outlined in the tables below.

Table 43: Data reference R02 - activity data for on road transport (excerpt)

Activity data by mode			Ref:	R02
LGA	LGA Code	Mode	Travel Bounds	Distance
				km
Wollongong	18450	MOTORCYCLE	INBOUND	12,453,154
Wollongong	18450	MOTORCYCLE	OUTBOUND	12,460,438
Wollongong	18450	MOTORCYCLE	TOTAL	24,913,591

Table 44: Data reference R03 - vehicle count by motive code

Vehicle count by Motive Power Code by LGA							Ref:	R03
Vehicle class	Vehicle subclass	MOTIVE POWER CODE						
		Unleaded petrol	Leaded petrol	Diesel	LPG and petrol hybrids	Other fuel types	Unknown	No engine
Wollongong								
Light Vehicles	Passenger Vehicles	76875	1151	5291	701	450	250	0
	Off-road Vehicles	24680	34	10677	414	71	26	0
	People movers	1359	30	427	10	1	0	0
	Small Buses	212	8	329	10	0	3	0
	Mobile Homes	167	15	212	6	0	3	0
	Motor cycles	7028	235	3	1	5	26	0
	Scooters	282	13	0	0	0	1	0
	Light Trucks	5370	221	12527	537	28	41	0
	Light Plants	3	3	11	1	0	1	0
	Light Trailers	0	0	0	0	0	0	21477
	Other Vehicles	1	0	0	0	0	0	0
	TOTAL	115977	1711	29476	1681	554	350	21477
Heavy Vehicles	Buses	3	0	129	0	0	0	0
	Heavy Trucks	12	1	1990	1	9	4	0
	Prime Movers	0	0	447	0	0	0	0
	Heavy Plants	0	0	78	0	1	0	0
	Heavy Trailers	0	0	0	0	0	0	944
	TOTAL	15	1	2644	1	10	4	944

Passenger vehicles	78613	1204	6259	727	451	256	0
Light commercial vehicles	5370	221	12527	537	28	41	0
Rigid trucks	12	1	1990	1	9	4	0
Articulated trucks	0	0	447	0	0	0	0

Table 45: Data reference R04 - fuel efficiency by vehicle class

Fuel efficiency of vehicles			Ref:	R04
Vehicle type	Petrol	Diesel	LPG/CNG/dual fuel/hybrid and other	Total
	l/100 km	l/100 km	l/100 km	l/100 km
All years				
Passenger vehicles	10.7	11.5	11.8	10.8
Motor cycles	5.8	0	0	5.8
Light commercial vehicles	12.8	12.3	16.8	12.5
Rigid trucks	20.9	28.7	19.4	28.6
Articulated trucks	0	55.2	0	55.2
Non-freight carrying trucks	14.5	21.3	0	21.3
Buses	20.4	29.1	29.9	28.4
Total	10.8	18.4	12.9	13.4

Table 46: Data reference R05 - emissions factors for transport fuels

Emissions from transport fuels				**Ref:**	**R05**
Transport equipment type	Fuel combusted	Energy content factor (GJ/kL unless otherwise indicated)	Emission factor kg CO2-e/GJ (relevant oxidation factors incorporated)		
			CO2	CH4	N2O
Post-2004 vehicles	Gasoline (other than for use as fuel in an aircraft)	34.2	67.4	0.02	0.2
	Diesel oil	38.6	69.9	0.01	0.6
	Liquefied petroleum gas	26.2	60.2	0.4	0.3
	Ethanol for use as fuel in an internal combustion engine	23.4	0	0.2	0.2

These data sets are then manipulated with the formulas outlined below.

Function F03

This function determines the composition of each vehicle class by fuel type and multiplies by the distance travelled to determine distance travelled by each vehicle class/fuel combination.

$$dist_{ij} = \frac{fleet_{ij}}{\sum fleet_i} \cdot dist_i$$

Where:

$dist_{ij}$ = Municipal distance travelled vehicle class i and fuel type j

$fleet_{ij}$ = Fleet size of vehicle class i and fuel type j

$fleet_i$ = Fleet size of vehicle class i

$dist_i$ = Municipal distance travelled by vehicle class i

Function F04

This function determines the amount of fuel consumed by each vehicle class and fuel type.

$$fuel_{ij} = \frac{dist_{ij}}{100} \cdot eff_{ij}$$

Where:

$fuel_{ij}$ = amount of fuel consumed by vehicle class i in fuel j

$dist_{ij}$ = Municipal distance travelled vehicle class i and fuel type j

eff_{ij} = Efficiency of vehicle class i in fuel type j (in litres/100km)

Function F05

This function converts fuel consumption by vehicle class and fuel type into carbon dioxide equivalent emissions.

$$emissions_{jg} = \sum_{i=0}^{m} e\_coeff_{jg} \cdot fuel_{ij}$$

Where:

$emissions_{jg}$ = carbon emissions for greenhouse gas 'g' from fuel type j (in CO_2e)

e_coeff_{jg} = carbon emissions factor for greenhouse gas 'g' from fuel type j

$fuel_{ij}$ = amount of fuel consumed by vehicle class i in fuel j

m = total number of vehicle classes

3.7 TR5: Rail Transport

3.7.1 Method TR5.1: Rail transport fuels by km travelled

This method utilizes Google transport activity data aggregated to the municipal boundary, and then applies a series of functions to convert this to estimated emissions. The activity data represents the movements of trains within the municipal boundary.

Trains present an interesting challenge for reporting emissions according to the GPC protocol, because their movements are not necessarily correlated to trips that originating and/or ending within the municipal boundary. For this reason, the preferred method for determining emissions is the Geographic/territorial (as outlined in Figure 7). Scope 1 emissions are for travel wholly within the boundary and for 50% of trip lengths for destinations outside of the boundary.

Method	Allocation principle	Scope 1	Scope 2	Scope 3
Fuel Sales Approach	Not applicable unless additional steps taken	All emission from fuel sold within boundary	Any electric charging station in the city boundary	Not applicable unless fuel sales allocated between scope 1 and 3 by specified method
City-induced Activity (e.g. US demand models)	Origin-Destination	In-boundary trips and in-boundary portion of 50% of transboundary trips (pass-through trips excluded)		Out-of-boundary portion of 50% of transboundary trip
		In-boundary trips and in-boundary portion of all departing transboundary trips (pass-through trips excluded)		Out-of-boundary portion of all departing transboundary trips
Geographic/ Territorial (e.g., European demand models)	Not applicable	All traffic occurring within city boundaries, regardless of origin or destination		Not applicable unless additional steps taken
Resident Activity	Options	Either resident activity is all scope 1, or use origin-destination		N/A or origin-destination used

Figure 7: Transport methods

Table 47: TR1.2 – Base data source

Data description	Granularity	Source	Source ID
Activity data by mode	State level	ABARES	TR-R1
Transport activity	State level	Google	EIE

User data requirements

None

Description of method

Passenger and freight emissions intensities are calculated based on BITRE's projections of total emissions and rail tasks for 2020 and are summarised in Table 48. Total rail emissions are calculated using the respective emission intensities multiplied by the total rail activity for that municipality in passenger kilometres.

Table 48: Summary of emissions intensity calculations

	Passenger[11]		Freight (total)
	Non-electric	Electric	
Direct greenhouse gas emissions (gigagrams of CO2 equivalent)	187.9	1490.6	3810.4
Rail tasks (billion passenger km (pkm) or billion tonne km)	2.749	13.391	506.42
Emissions intensity (kgCO2e/pkm or kgCO2e/tonne·km)	0.07	0.11	0.01

Table 49: References for train emissions intensity calculations

Name of Source Document	Location in Document	Author(s)	Date of Pub	URL
Greenhouse gas emissions from Australian transport: projections to 2020	Tables 2.3, A25	BITRE	2009	https://www.bitre.gov.au/sites/default/files/wp_073.pdf
Trainline 7	Tables 21, 23	BITRE	2019	https://www.bitre.gov.au/sites/default/files/publications/train_007.pdf

Scaling

State-level data is scaled using relevant factors to represent municipal level fuel consumption figures.

The data is then scaled temporally if needed to correlate to the inventory year. The scaling methods applied are:

Petrol: Scaled by population growth
Diesel: Scaled by GRP growth
LPG/Dual/Other: Scaled by GRP growth

Emissions are determined by the following steps:

- Carbon dioxide equivalent emissions are determined through the use of the figures published by the Australian federal government – National Greenhouse Accounting Factors
- These figures are provided for average gas emissions associated with consumption of each of the different fuel types

[11] Assumes the 7% of non-electric urban rail infrastructure and 6% of electric non-urban rail line are negligible and divides non-electric and electric rail into non-urban and urban respectively. (source: Trainline 7)

3.8 Transport Scaling methods

population growth rate

Data
The population growth rate is determined using ABS supplied population figures.

Table 50: Scaling methods, population growth rate - data sources

Data description	Granularity	Source	Source ID
Whole population	LGA level	Australian Bureau of Statistics	BM-R1

Special notes:

- From this source, population data for 2006, 2011, and 2016 (census years) are used (to avoid using interpolated data).

Method
From this data, a linear regression is done correlating the population to the years. This linear regression produces a constant and a coefficient. Together these can be applied to any year to estimate the projected population.

Commercial job growth rate

Data
The commercial job growth rate is determined using ABS supplied employment figures.

Table 51: Scaling methods, population growth rate - data sources

Data description	Granularity	Source	Source ID
Commercial Jobs	LGA level	Australian Bureau of Statistics	BM-R2

Special notes:

- Employment figures need to be derived from the 'Place of Work' dataset, rather than the 'Place of Residence' dataset
- From this source, commercial job data from 2011 and 2016 (census years) is used (to avoid using interpolated data).

Method
From this data, a linear regression is done correlating the number of jobs to the years. This linear regression produces a constant and a coefficient. Together these can be applied to any year to estimate the projected number of jobs.

Greenhouse Gas Ratios for Electricity

Carbon emissions conversion factors from the National Greenhouse Accounts do not split out by specific gas. To do this, the following method is applied:

Data

Table 52: Data source for GHG ratios for electricity

Data description	Granularity	Source	Source ID
Electricity breakdown by generation source and gas	State-level	Department of Energy and Environment	SE-R2
Emissions factors by greenhouse gas for specific generation fuels	State-level	Department of Energy and Environment	GHG-R1

Method

This breakdown is done by the following steps:

- The total amount of energy generated by each fuel type is multiplied by the emissions factors by greenhouse gas for the specific fuel type
- This produces totals for each greenhouse gas by state (in CO_2e)
- These totals for each gas are then divided by the total overall to determine the specific percentage of the gas of total CO_2e by state

4. Waste

Waste covers emissions associated with the breakdown of waste materials. There are two primary categories of waste that apply to the GPC BASIC profile: Solid Waste and Wastewater.

4.1 WS1: Solid Waste

The following methods can be applied, depending on the availability of data.

Table 53: WS1 - Methods

Method	Data quality assessment			Key data requirement
	Data quality	Activity data	Emissions factors	
WS1.4	Medium	Modelled activity data using robust assumptions	More general emission factors	Using state level data, broken down into streams

4.1.1 Method WS1.4: Municipal waste scaled from state totals

This method takes data from the Waste generation and resource recovery in Australia, a study developed by Randall Environmental Consulting. This report breaks down solid waste generation by sector (residential, commercial/industrial, and construction/demolition).

Data requirements

- Information on the type of green waste diversion provided by Council (e.g. regular collection of green organics), or municipality specific information about the composition of the waste stream.
- Information on where the waste is treated (i.e. inside or outside of municipal boundaries).

Description of method

State level data is scaled using relevant factors to represent waste generation for the municipality. The following scaling factors are used to achieve this:

- Municipal: Scaled by ratio of population Municipality/State
- Commercial and industrial (C&I): Municipality/State — Scaled by ratio of commercial jobs
- Construction and demolition (C&D): Municipality/State — Scaled by ratio of building approvals

The data is then scaled temporally if needed to correlate to the inventory year. The scaling methods applied are:

- Municipal: Scaled by population growth
- C&I: Scaled by job growth
- C&D: Scaled by growth of building approvals

Emissions are determined by the following steps:

- Carbon dioxide equivalent emissions are determined through the use of the figures published by the Australian federal government – National Greenhouse Accounting Factors
- These figures are provided for average gas emissions associated with waste breakdowns.
- The waste mix is taken from the Australian Government's National Greenhouse & Energy Reporting Scheme (NGERS) Determination, which provides default waste mixes. For municipal waste, the default waste mix varies depending on whether organics collection occurs.
- The emissions are adjusted to take into account waste treatment by applying a correction for waste treatment based on the state-level data.

Issues and considerations

- This method assumes that the scaling factors used for moving from the state to municipal levels are appropriate, which may not be accurate for the specific municipality.
- For future profiles, this method increases the difficulty of noting any differences in consumption patterns specific to the municipality. For this reason in particular, this method should be sought to be replaced with other methods as soon as possible.
- This method assumes that treatment of waste is consistent with the categorizations of the NGERS standard.

4.2 WS2: Wastewater

The following methods can be applied, depending on the availability of data.

Table 54: WS2 - Methods

Method	Data quality assessment			Key data requirement
	Data quality	Activity data	Emissions factors	
WS2.2	Medium	Modelled activity data using robust assumptions	More general emission factors	Using National Carbon Inventory scaled to municipality

4.2.1 Method WS2.2: Wastewater emissions derived from state level data

This method takes data from the Australian National Greenhouse Inventory for wastewater emissions, broken down by state. It scales the emissions data according to population

Data requirements

- Information on whether wastewater treatment predominantly happens inside or outside of municipal boundaries.

Description of method

State level data is scaled using relevant factors to represent waste generation for the municipality. The following scaling factors are used to achieve this:

- Total: Scaled by ratio of population Municipality/State

The data is then scaled temporally if needed to correlate to the inventory year. The scaling method applied is:

- Total: Scaled by population growth

Emissions are determined by the following steps:

- Carbon dioxide equivalent emissions are determined through the use of the figures published by the Australian federal government – National Greenhouse Accounting Factors. These figures are provided for average gas emissions associated with waste breakdowns.

Issues and considerations

- This method assumes that the scaling factors used for moving from the state to municipal levels are appropriate, which may not be accurate for the specific municipality.
- For future profiles, this method increases the difficulty of noting any differences in generation patterns specific to the municipality. For this reason in particular, this method should be sought to be replaced with other methods as soon as possible.

5. Agriculture, Forestry & Other Land Use

The Agriculture, Forestry and Other Land Use (AFOLU) sector produces GHG emissions through a variety of pathways, including land-use changes that alter the composition of the soil, methane produced in the digestive processes of livestock, and nutrient management for agricultural purposes.

At this stage, not all emissions sources for agriculture have been included. The determination has been if the source accounts for 1% or more of total agricultural emissions. It should be noted that, even though emissions from a particular source may be below 5% (such as for rice cultivation) it is possible that it may be more significant for specific regions. To this end, the additional sources will be added as soon as possible.

Table 55: AG - Agricultural methods inclusions

Total emissions for agricultural sources			
Emissions source	**Total Australian emissions (kt CO2e)**	**Proportion of agriculture**	**Included**
Enteric Fermentation	14,677.52	80.22%	Yes
Manure Management	987.88	5.40%	Yes
Rice Cultivation	5.47	0.03%	No
Agricultural Soils	2,308.71	12.62%	Yes
Prescribed Burning of Savannas	Data is not available		No
Field Burning of Agricultural Residues	39.07	0.21%	No
Liming	31.97	0.17%	No
Urea Application	245.84	1.34%	No

Other Carbon-containing Fertilisers	Data is not available		No

5.1 AG1: Enteric Fermentation

The following methods can be applied, depending on the availability of data.

Table 56: AG1 - Methods

Method	Data quality assessment			Key data requirement
	Data quality	Activity data	Emissions factors	
AG1.1	High	Detailed Activity Data	Default emission factors	None

5.1.1 Method AG1.1: ABS SA2 level data scaled to municipality

Description of method

This method uses activity data collected at the ABS Statistical Area Level 2 (SA2) and allocates this to the municipality by intersecting LGA boundaries and SA2 boundaries.

To identify the specific area of these SA2 regions that apply to a municipality, an intersection was plotted between SA2 boundaries and the LGA municipal boundaries – to identify the concordances by postcode. With this concordance information, emissions were estimated.

Enteric fermentation is calculated using the Tier 1 calculation method from the IPCC Emissions Calculations Guidelines. It is described as follows:

> *Tier 1 is a simplified approach that relies on default emission factors drawn from previous studies. The Tier 1 approach is likely to be sufficient for most animal types in most countries.*

This method is:

$$E_{ls} = \frac{EF_{ls} \times P}{1000000}$$

Where:

E_{ls} = Emissions from livestock (in Gg CO2e)
P = Head of livestock
EF_{ls} = Emissions Factor for livestock

The emissions factor is determined from the follow table[12]:

Table 57: AG1.1 - Fermentation Emissions Factors

[12] Derived from tables 10.10 and 10.11, Pg.10.28-10.29, 2006 IPCC Guidelines for National Greenhouse Gas Inventories

Enteric Fermentation Emissions Factors for livestock			
Zone	**Category**	**Emission Factor (kg/head/yr)**	**Notes**
Oceania	Dairy	90	Average milk production of 2,200 kg/head/yr.
	Non-dairy	60	Includes beef cows, bulls, and young.
	Sheep	8	
	Swine	1.5	

Data requirements

Head of livestock and emissions factor for livestock

Scaling and adjustments to activity data

To undertake spatial scaling, an intersection was plotted between SA2 boundaries and the LGA municipal boundaries to identify the specific area to apply to a municipality. With this concordance information, Livestock numbers were estimated.

The data is scaled temporally if needed to correlate to the inventory year. The scaling methods applied are based on a regression of actual time series emissions data.

5.2 AG2: Manure Management

The following methods can be applied, depending on the availability of data.

Table 58: AG2 - Methods

Method	Data quality assessment			Key data requirement
	Data quality	Activity data	Emissions factors	
AG2.1	High	Detailed Activity Data	Default emission factors	Using SA2 level agricultural commodities data applied to IPCC Tier 1 methods

5.2.1 Method AG2.1: ABS SA2 level data scaled to municipality

Identical to enteric fermentation, manure management is determined using the Tier 1 calculation method from the IPCC Emissions Calculations Guidelines. It is described as follows:

> *Tier 1 is a simplified approach that relies on default emission factors drawn from previous studies. The Tier 1 approach is likely to be sufficient for most animal types in most countries.*

This method is:

$$E_{ls} = \frac{EF_{ls} \times P}{1000000}$$

Where:

E_{ls}	=	Emissions from livestock (in Gg CO2e)
P	=	Head of livestock
EF_{ls}	=	Emissions Factor for livestock

The emissions factor is determined from the follow table[13]:

Table 59: AG2.1 - Fermentation Emissions Factors

Manure management emissions factors			
Category	**Emissions Factor (kg CO_2e/head)**		
	Cool	**Temp**	**Warm**
Sheep	0.19	0.28	0.37
Dairy Cattle*	26	30	31
Non-Dairy Cattle*	1	2	2
Swine*	22	24	24

*Note where there is a range of emissions factors within each temperature band, we have taken the conservative approach of using the highest emissions factor in our calculations.

Data requirements

Head of livestock and emissions factor for livestock

Scaling and adjustments to activity data

To undertake spatial scaling, an intersection was plotted between SA2 boundaries and the LGA municipal boundaries to identify the specific area to apply to a municipality. With this concordance information, Livestock numbers were estimated.

The data is scaled temporally if needed to correlate to the inventory year. The scaling methods applied are based on a regression of actual time series emissions data.

Updates

Profiles from 2018 onwards include emissions from manure management from poultry.

[13] Derived from tables 10.14 and 10.15, Pg.10.39-10.40, 2006 IPCC Guidelines for National Greenhouse Gas Inventories

5.3 AG3: Agricultural Soils

The following methods can be applied, depending on the availability of data. This method is still being investigated so to improve completeness of reporting.

Table 60: AG3 - Methods

Method	Data quality assessment			Key data requirement
	Data quality	Activity data	Emissions factors	
AG3.1	TBC	TBC	TBC	TBC

Emissions from agricultural soils was previously allocated according to total crops. For profiles from 2018 onwards this has been resolved according to the following table:

Category	Year	Agricultural commodity
Total Crops	2015/16	Crops - Total crops (including broadacre, hay, silage and horticulture) - Area (ha)
	2016/17	Crops - Total crops (including broadacre, hay, silage and horticulture) - Area (ha)
	2017/18	Crops - Total crops (including broadacre, hay, silage and horticulture) - Area (ha)
	2018/19	Crops - Total crops (including broadacre, hay, silage and horticulture) - Area (ha)
Rice	2015/16	Broadacre crops - Cereal crops - Rice for grain - Area (ha)
	2016/17	Broadacre crops - Cereal crops - Rice for grain - Area (ha)
	2017/18	Broadacre crops - Cereal crops - Rice for grain - Area (ha)
	2018/19	Broadacre crops - Cereal crops - Rice for grain - Area (ha)
Cotton	2015/16	Broadacre crops - Non-cereal crops - Cotton (irrigated and non-irrigated) - Area (ha)
	2016/17	Broadacre crops - Non-cereal crops - Cotton (irrigated and non-irrigated) - Area (ha)
	2017/18	Broadacre crops - Non-cereal crops - Cotton (irrigated and non-irrigated) - Area (ha)
	2018/19	Broadacre crops - Non-cereal crops - Cotton (irrigated and non-irrigated) - Area (ha)
Sugarcane	2015/16	Broadacre crops - Non-cereal crops - Sugar cane - Total - Area (ha)
	2016/17	Broadacre crops - Non-cereal crops - Sugar cane - Total - Area (ha)
	2017/18	Broadacre crops - Non-cereal crops - Sugar cane - Total - Area (ha)
	2018/19	Broadacre crops - Non-cereal crops - Sugar cane - Total area (ha)
Vegetables	2015/16	Vegetables for human consumption - Total - Area (ha)
	2016/17	Vegetables for human consumption - Total - Area (ha)

	2017/18	Vegetables for human consumption - Total - Area (ha)
	2018/19	Vegetables for human consumption - Total - Area (ha)
Hay and Pasture	2015/16	Hay and Silage - Pasture (including lucerne), cereal and other crops cut for hay - Total - Area (ha)
	2016/17	Hay and Silage - Total crops cut for hay - Area (ha)
	2017/18	Hay and Silage - Total crops cut for hay - Area (ha)
	2018/19	Hay and silage - Total crops cut for hay and silage - Area (ha)
Other Broadacre	2015/16	Total crops - (rice, cotton, sugarcane, vegetables, and hay and silage)
	2016/17	Total crops - (rice, cotton, sugarcane, vegetables, and hay and silage)
	2017/18	Total crops - (rice, cotton, sugarcane, vegetables, and hay and silage)
	2018/19	Total crops - (rice, cotton, sugarcane, vegetables, and hay and silage)

These proportions are then allocated according to the subcategories of nitrogen use in the National Greenhouse Inventory activity table for agricultural soils.

5.4 AG: Inter Year Scaling

Agricultural methods have been updated to incorporate inter-year scaling through applying SA4 data for agricultural commodities. This introduces a scaling ratio (i.e a percentage) to adjust the SA2 levels. Because the SA4 data is incomplete for some localities, additional interpolation is required. Interpolation is a follows:

- If there is a 1 year gap, the value is estimated as the average of the adjacent years
- If there is a two year gap, the value is estimated as a linear interpolation for the intervening two years
- If there is only one data value, then this value is assumed to apply to all missing years
- If the value is n.p. then it is assumed to be 0 (zero)

5.5 LU1: Land Clearing

The following methods can be applied, depending on the availability of data.

Table 61: LU1 - Methods

Method	Data quality assessment			Key data requirement
	Data quality	Activity data	Emissions factors	
AG3.1	Low	Highly modelled or uncertain activity data	More general emission factors	None

5.5.1 Method LU1.1

This method uses activity data collected at the bioregion (IBRA7) and allocates this to the municipality by intersecting LGA boundaries and IBRA7 region boundaries.

Land use changes are not recorded at the LGA (Local Government Area) level by the federal government. Instead, it is collated by Bioregion (IBRA7). To identify the specific area of these bioregions to apply to a municipality, an intersection was plotted between IBRA7 region boundaries and the LGA municipal boundaries – to identify the concordances by postcode. With this concordance information, biomass transfers were estimated through the following methods.

Description of method

This method uses bioregion level data as the starting activity data and basis of its calculations:

Table 62: LU1.1 – Base data source

Data description	Granularity	Source	Source ID
Primary conversion area by kha	Bioregion (IBRA7)	Department of Environment and Energy	LU-R2
Re-clearing area by kha	Bioregion (IBRA7)	Department of Environment and Energy	LU-R2

Data sources

- Australian Federal Government, Department of Environment and Energy
- Australian Bureau of Statistics
- ABARES
- IPCC Carbon Emissions Guidelines 2006

Scaling and adjustments to activity data

To undertake spatial scaling, an intersection was plotted between IBRA7 region boundaries and the LGA municipal boundaries to identify the specific area of these bioregions to apply to a municipality. With this concordance information, biomass transfers were estimated.

The data is scaled temporally if needed to correlate to the inventory year. The scaling methods applied for primary conversion and reclearing regrowing is based on scaling historic data (kHa affected from 2014 to 2016).

To estimate losses from primary conversion and re-clearing

To estimate these losses, the following formula was used:

EQUATION 2.14
ANNUAL CARBON LOSSES IN BIOMASS DUE TO DISTURBANCES

$$L_{disturbance} = \{A_{disturbance} \bullet B_W \bullet (1+R) \bullet CF \bullet fd\}$$

/here:

$L_{disturbances}$ = annual other losses of carbon, tonnes C yr^{-1} (Note that this is the amount of biomass that is lost from the total biomass. The partitioning of biomass that is transferred to dead organic matter and biomass that is oxidized and released to the atmosphere is explained in Equations 2.15 and 2.16).

$A_{disturbance}$ = area affected by disturbances, ha yr^{-1}

B_W = average above-ground biomass of land areas affected by disturbances, tonnes d.m. ha^{-1}

R = ratio of below-ground biomass to above-ground biomass, in tonne d.m. below-ground biomass (tonne d.m. above-ground biomass)$^{-1}$. R must be set to zero if no changes of below-ground biomass are assumed (Tier 1)

CF = carbon fraction of dry matter, tonne C (tonnes d.m.)$^{-1}$

fd = fraction of biomass lost in disturbance (see note below)

Note: The parameter fd defines the proportion of biomass that is lost from the biomass pool: a standreplacing disturbance will kill all (fd = 1) biomass while an insect disturbance may only remove a portion (e.g. fd = 0.3) of the average biomass C density. Equation 2.14 does not specify the fate of the carbon removed from the biomass carbon stock. The Tier 1 assumption is that all of Ldisturbances is emitted in the year of disturbance. Higher Tier methods assume that some of this carbon is emitted immediately and some is added to the dead organic matter pools (dead wood, litter) or HWP.

Reference: IPCC Carbon emissions guidelines 2006, volume 4, chapter 2[14]

To estimate the amount of embedded carbon was in the forests being cleared (Bw), the following assumptions were use:

[14] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf

TABLE 4.7 (CONTINUED) ABOVE-GROUND BIOMASS IN FORESTS				
Domain	**Ecological zone**	**Continent**	**Above-ground biomass (tonnes d.m. ha^{-1})**	**References**
Temperate	Temperate oceanic forest	Europe	120	-
		North America	660 (80-1200)	Hessl *et al.*, 2004; Smithwick *et al.*, 2002
		New Zealand	360 (210-430)	Hall *et al.*, 2001
		South America	180 (90-310)	Gayoso and Schlegel, 2003; Battles *et al.*, 2002
	Temperate continental forest	Asia, Europe (≤20 y)	20	IPCC, 2003
		Asia, Europe (>20 y)	120 (20-320)	IPCC, 2003
		North and South America (≤20 y)	60 (10-130)	IPCC, 2003
		North and South America (>20 y)	130 (50-200)	IPCC, 2003
	Temperate mountain systems	Asia, Europe (≤20 y)	100 (20-180)	IPCC, 2003
		Asia, Europe (>20 y)	130 (20-600)	IPCC, 2003
		North and South America (≤20 y)	50 (20-110)	IPCC, 2003
		North and South America (>20 y)	130 (40-280)	IPCC, 2003
Boreal	Boreal coniferous forest	Asia, Europe, North America	10-90	Gower *et al.*, 2001
	Boreal tundra woodland	Asia, Europe, North America (≤20 y)	3-4	IPCC, 2003
		Asia, Europe, North America (>20 y)	15-20	IPCC, 2003
	Boreal mountain systems	Asia, Europe, North America (≤20 y)	12-15	IPCC, 2003
		Asia, Europe, North America (>20 y)	40-50	IPCC, 2003

Reference: IPCC Carbon emissions guidelines 2006, volume 4, chapter 2[15]

The relevant cells are highlighted. We are using the 'less than 20 years' category for reclearing locations, and 'greater than 20 years' category for primary conversion.

The below-ground biomass contribution was identified with the following table:

[15] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf

TABLE 4.4
RATIO OF BELOW-GROUND BIOMASS TO ABOVE-GROUND BIOMASS (R)

Domain	Ecological zone	Above-ground biomass	R [tonne root d.m. (tonne shoot d.m.)$^{-1}$]	References
Tropical	Tropical rainforest		0.37	Fittkau and Klinge, 1973
	Tropical moist deciduous forest	above-ground biomass <125 tonnes ha^{-1}	0.20 (0.09 - 0.25)	Mokany *et al.*, 2006
		above-ground biomass >125 tonnes ha^{-1}	0.24 (0.22 - 0.33)	Mokany *et al.*, 2006
	Tropical dry forest	above-ground biomass <20 tonnes ha^{-1}	0.56 (0.28 - 0.68)	Mokany *et al.*, 2006
		above-ground biomass >20 tonnes ha^{-1}	0.28 (0.27 - 0.28)	Mokany *et al.*, 2006
	Tropical shrubland		0.40	Poupon, 1980
	Tropical mountain systems		0.27 (0.27 - 0.28)	Singh *et al.*, 1994
Subtropical	Subtropical humid forest	above-ground biomass <125 tonnes ha^{-1}	0.20 (0.09 - 0.25)	Mokany *et al.*, 2006
		above-ground biomass >125 tonnes ha^{-1}	0.24 (0.22 - 0.33)	Mokany *et al.*, 2006
	Subtropical dry forest	above-ground biomass <20 tonnes ha^{-1}	0.56 (0.28 - 0.68)	Mokany *et al.*, 2006
		above-ground biomass >20 tonnes ha^{-1}	0.28 (0.27 - 0.28)	Mokany *et al.*, 2006
	Subtropical steppe		0.32 (0.26 - 0.71)	Mokany *et al.*, 2006
	Subtropical mountain systems		no estimate available	
Temperate	Temperate oceanic forest, Temperate continental forest, Temperate mountain systems	conifers above-ground biomass < 50 tonnes ha^{-1}	0.40 (0.21 - 1.06)	Mokany *et al.*, 2006
		conifers above-ground biomass 50-150 tonnes ha^{-1}	0.29 (0.24 - 0.50)	Mokany *et al.*, 2006
		conifers above-ground biomass > 150 tonnes ha^{-1}	0.20 (0.12 - 0.49)	Mokany *et al.*, 2006
		Quercus spp. above-ground biomass >70 tonnes ha^{-1}	0.30 (0.20 - 1.16)	Mokany *et al.*, 2006
		Eucalyptus spp. above-ground biomass < 50 tonnes ha^{-1}	0.44 (0.29 - 0.81)	Mokany *et al.*, 2006
		Eucalyptus spp. above-ground biomass 50-150 tonnes ha^{-1}	0.28 (0.15 - 0.81)	Mokany *et al.*, 2006
		Eucalyptus spp. above-ground biomass > 150 tonnes ha^{-1}	0.20 (0.10 - 0.33)	Mokany *et al.*, 2006
		other broadleaf above-ground biomass < 75 tonnes ha^{-1}	0.46 (0.12 - 0.93)	Mokany *et al.*, 2006
		other broadleaf above-ground biomass 75-150 tonnes ha^{-1}	0.23 (0.13 - 0.37)	Mokany *et al.*, 2006
		other broadleaf above-ground biomass >150 tonnes ha^{-1}	0.24 (0.17 - 0.44)	Mokany *et al.*, 2006

The 'less than 50 tonnes' category was used for reclearing losses, while the 'greater than 50 tonnes' category was used for new conversion losses.

Additional assumptions include:

- The fraction of biomass disturbs was assumed to be 1.
- The carbon factor was assumed to be 0.5.

Issues and considerations

This method assumes that the annual change in the area of land affected from 2014 to 2016 is a good predictor of future land areas affected. This may not be correct as the area of land affected in primary conversion, reclearing and forest regrowing can vary significantly from year to year.

5.6 LU2: Afforestation

The following methods can be applied, depending on the availability of data.

Table 63: LU2 - Afforestation

Method	Data quality assessment			Key data requirement
	Data quality	Activity data	Emissions factors	
AG3.1	Low	Highly modelled or uncertain activity data	More general emission factors	None

5.6.1 Method LU2.1

This method uses activity data collected at the bioregion (IBRA7) and allocates this to the municipality by intersecting LGA boundaries and IBRA7 region boundaries.

Land use changes are not recorded at the LGA (Local Government Area) level by the federal government. Instead, it is collated by Bioregion (IBRA7). To identify the specific area of these bioregions to apply to a municipality, an intersection was plotted between IBRA7 region boundaries and the LGA municipal boundaries – to identify the concordances by postcode. With this concordance information, biomass transfers were estimated through the following methods.

Data sources

- Australian Federal Government, Department of Environment and Energy
- Australian Bureau of Statistics
- ABARES
- IPCC Carbon Emissions Guidelines 2006

Description of method

Starting activity data
This method uses bioregion level data for the basis of its calculations:

Table 64: LU2.1 – Base data source

Data description	Granularity	Source	Source ID
Forest regrowing by kha	Bioregion (IBRA7)	Department of Environment and Energy	LU-R2

Scaling and adjustments to activity data

To undertake spatial scaling, an intersection was plotted between IBRA7 region boundaries and the LGA municipal boundaries to identify the specific area of these bioregions to apply to a municipality. With this concordance information, biomass transfers were estimated.

The data is scaled temporally if needed to correlate to the inventory year. The scaling methods applied for forest regrowing is based on scaling historic data (kHa affected from 2014 to 2016).

To estimate gains from forest regrowing

To estimate gains, tonnes of dry matter per Ha was converted to carbon and then to carbon emissions per Ha. This is then multiplied by "ratio of below to above ground biomass" for "Eucalyptus spp. aboveground biomass < 50 tonnes ha-1" to calculate the removal of greenhouse gas emissions from forest regrowth.

Issues and considerations

This method assumes that the annual change in the area of land affected from 2014 to 2016 is a good predictor of future land areas affected. This may not be correct as the area of land affected in primary conversion, reclearing and forest regrowing can vary significantly from year to year. The characteristics of the greenhouse gas inventory estimate of Forest Land can have different level of precision, accuracy and levels of bias. Moreover, the estimates are influenced by the quality and consistency of data and information available in a country, as well as gaps in knowledge. In addition, depending on the tier level used by a country, estimates can be affected by different sources of errors, such as sampling errors, assessment errors, classification errors in remote sensing imagery, and modeling errors that can propagate to the total estimation.

6. Appendix I: Scaling methods

population growth rate

Data

The population growth rate is determined using ABS supplied population figures.

Table 65: Scaling methods, population growth rate - data sources

Data description	Granularity	Source	Source ID
Whole population	LGA level	Australian Bureau of Statistics	BM-R1

Special notes:

- From this source, population data for 2006, 2011, and 2016 (census years) are used (to avoid using interpolated data).

Method

From this data, a linear regression is done correlating the population to the years. This linear regression produces a constant and a coefficient. Together these can be applied to any year to estimate the projected population.

Commercial job growth rate

Data

The commercial job growth rate is determined using ABS supplied employment figures.

Table 66: Scaling methods, population growth rate - data sources

Data description	Granularity	Source	Source ID
Commercial Jobs	LGA level	Australian Bureau of Statistics	BM-R2

Special notes:

- Employment figures need to be derived from the 'Place of Work' dataset, rather than the 'Place of Residence' dataset
- From this source, commercial job data from 2011 and 2016 (census years) is used (to avoid using interpolated data).

Method

From this data, a linear regression is done correlating the number of jobs to the years. This linear regression produces a constant and a coefficient. Together these can be applied to any year to estimate the projected number of jobs.

Greenhouse Gas Ratios for Electricity

Carbon emissions conversion factors from the National Greenhouse Accounts do not split out by specific gas. To do this, the following method is applied:

Data

Table 67: Data source for GHG ratios for electricity

Data description	Granularity	Source	Source ID
Electricity breakdown by generation source and gas	State-level	Department of Energy and Environment	SE-R2
Emissions factors by greenhouse gas for specific generation fuels	State-level	Department of Energy and Environment	GHG-R1

Method

This breakdown is done by the following steps:

- The total amount of energy generated by each fuel type is multiplied by the emissions factors by greenhouse gas for the specific fuel type
- This produces totals for each greenhouse gas by state (in CO_2e)
- These totals for each gas are then divided by the total overall to determine the specific percentage of the gas of total CO_2e by state

7. Appendix II: Regressions

7.1 SE-REG1

This regression establishes a relationship between actual LGA-scale datasets and the apportioned breakdowns from state totals using the established metrics of population and employment figures. The reason why this regression is needed is because there appears to be a discrepancy between DNSP reported LGA-scale consumption data and the state totals – this means that from the data collected to date, if all of the DNSPs reported data for every municipality in each state, the total would be less than the reported total consumption collated by the Australian Energy Market Operator. The reason for this discrepancy is unclear, though current thinking is that it is due to number of unreported high consumption users.

The regression is based on the following dataset:

	Yarra	Whittlesea	Nillumbik	Moreland	Melbourne	Hume	Darebin	Banyule	Manningham
Actual (kWh)	489,528	392,567	82,732	303,417	2,321,533	1,236,051	432,679	254,563	166,207
Base scaled (kWh)	1,018,631	544,317	133,615	444,501	7,582,471	1,125,733	554,228	446,137	363,232

Reference: SE-R7

The resulting regression is as follows:

	Regression A	Regression C
Based scaled to revised scaled	0.283030067	246963.1755

7.2 SE-REG2

This regression establishes a relationship between total commercial and industrial electricity consumption and the individual subsectors. The reason why this regression is needed is as identified above for SE-REG2 and is needed to appropriately allocate electricity to the commercial and industrial subsectors.

The regression is based on the following dataset:

	Yarra	Whittlesea	Nillumbik	Moreland	Melbourne	Hume	Darebin	Banyule	Manningham
Actual (kWh)	489,528	392,567	82,732	303,417	2,321,533	1,236,051	432,679	254,563	166,207
Base scaled (kWh)	1,018,631	544,317	133,615	444,501	7,582,471	1,125,733	554,228	446,137	363,232

Reference: SE-R7

The resulting quadratic regression is as follows:

	Regression A	Regression B	Regression C
Based scaled to revised scaled	-9.54395E-08	1.049285083	-146511.0573

7.3 SE-REG3

This regression establishes a relationship between residential electricity consumption for Australia and overall population. It is designed to reflect the change in per capita energy use and is to correct for changes in use over time. It uses the following dataset:

Total energy use										
Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Residential (PJ)	217.2	218.6	220.1	219.9	221.8	224.2	228.5	230.0	230.9	233.8
Population	20,827,622	21,249,199	21,691,653	22,031,750	22,340,024	22,733,465	23,128,129	23,475,686	23,815,995	24,190,907

Reference: BM-R7, BM-R8, GHG-R16

It establishes the following regression:

	Reg A	Reg C
Residential energy density	-0.10	220.45

7.4 SE-REG4

This regression establishes a relationship between commercial electricity consumption for Australia and overall employment in the commercial sector. It is designed to reflect the change in per commercial job energy use and is to correct for changes in use over time. It uses the following dataset:

Total energy use								
Year	2009	2010	2011	2012	2013	2014	2015	2016
Commercial (PJ)	81	84	86	89	92	98	101	105
Labour force ('000s)	10,786	10,905	11,172	11,276	11,432	11,479	11,642	11,944
Energy per job (GJ)	7.55	7.68	7.72	7.87	8.04	8.57	8.72	8.76

Reference: BM-R7, BM-R8, GHG-R16

It establishes the following regression:

	Reg A	Reg C
Commercial energy density	0.19	-383.37

7.5 SE-REG5

This regression establishes the trend in emissions intensity of grid-supplied electricity over time. It uses the following dataset:

Electricity emissions			
	Scope 2	**Scope 3**	**Total**
Year	**kg CO2e/kWh**	**kg CO2e/kWh**	**kg CO2e/kWh**
2005.5	0.92	0.11	1.03
2006.5	0.92	0.11	1.03
2007.5	0.92	0.12	1.04
2008.5	0.92	0.12	1.04
2009.5	0.9	0.12	1.02

2010.5	0.88	0.12	1
2011.5	0.87	0.12	0.99
2012.5	0.85	0.11	0.96
2014.5	0.83	0.12	0.95
2014.5	0.81	0.11	0.92
2015.5	0.81	0.11	0.92

Reference: GHG-R2

It establishes the following regression:

	Reg A	Reg C
Electricity energy density	(0.01)	27.47

7.6 SE-REG6

This regression is used in method SE1.5. It uses Ausgrid electricity consumption data for 32 municipalities in NSW (Reference Source SE-R10) to establish a relationship between municipal residential electricity consumption (MWh) and the following explanatory variables (sourced from ABS datasets):

- Population
- Number of Households
- Density (persons/km^2)
- SEIFA index
- Dwelling structure (% of dwellings that are detached or semi-detached)

The regression is as follows:

Explanatory variable	*Coefficients*	*Standard Error*	*t Stat*	*P-value*
Intercept	-39,677.97	92,540.53	-0.43	0.67
Population	1.09	0.46	2.35	0.03
Households	3.10	1.19	2.60	0.02
Density	-17.97	5.75	-3.13	0.00
SEIFA (percentage)	868.13	482.47	1.80	0.09
Dwelling structure	39,513.66	79,068.53	0.50	0.62

7.7 SE-REG7

This regression is used in method SE1.5. It uses Ausgrid electricity consumption data for 32 municipalities in NSW (Reference Source SE-R10) to establish a relationship between municipal commercial electricity consumption (MWh) and the following explanatory variables (sourced from ABS datasets):

- Number of commercial jobs
- GRP ($)
- Number of businesses

Note that commercial electricity consumption is derived by adding together the following values from the dataset:

- Non-residential small-medium sites (0-160 MWh pa)
- Unmetered supply (eg. street lighting)

The following regression is established:

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	12,561.78	6,155.64	2.04	0.05
Commercial jobs	2.31	0.51	4.51	0.00
GRP	-4.23	1.69	-2.50	0.02
No. of Businesses	3.82	1.44	2.66	0.01

7.8 SE-REG8

This regression is used in method SE1.5. It uses Ausgrid electricity consumption data for 32 municipalities in NSW (Reference Source SE-R10) to establish a relationship between municipal industrial electricity consumption (MWh) and the following explanatory variables (sourced from ABS datasets):

- Number of industrial jobs
- GRP ($)
- Number of businesses

Note that industrial electricity consumption is derived by adding together the following values from the dataset:

- Non-residential large sites (>160 MWh pa)
- Number of customers at non-residential large sites x Average use from high voltage customers. (High voltage customers are not reported at the municipal level so we have assumed their usage is distributed evenly through the reporting region)

The following regression is established:

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-31,678.09	18,425.61	-1.72	0.10
Industrial jobs	9.41	5.86	1.60	0.12
GRP	29.71	0.78	38.03	0.00
No. of Businesses	37.24	7.37	5.05	0.00

8. Appendix III: References

Reference	Name of Source Document	Location in Document	Author(s)	Date of Publication	URL
AG-R1	Ironbark Sustainability expert assessment	n/a	n/a	n/a	n/a
AG-R2	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories	Table 11.1	IPCC	2006	https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_11_Ch11_N2O&CO2.pdf
AG-R3	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories	Tables 4-3 and 4-4, Pg.10-11	IPCC	2006	https://www.ipcc-nggip.iges.or.jp/public/gl/invs6c.html
AG-R4	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories	Tables 4-5 and 4-6, Pg.12-13	IPCC	2006	https://www.ipcc-nggip.iges.or.jp/public/gl/invs6c.html
AG-R5	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories	Table 4-19, Pg.94	IPCC	2006	https://www.ipcc-nggip.iges.or.jp/public/gl/invs6c.html
AG-R6	Agricultural commodities, Australia and state/territory and LGA regions – 2018/19	n/a	Australian Bureau of Statistics	2020	https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/7121.02015-16?OpenDocument
AG-R7	National Greenhouse Inventory	n/a	Australian Department of Environment and Energy	06/2021	http://ageis.climatechange.gov.au/
AG-R8	Activity Table 1990-2016 - Agriculture - Fertiliser	n/a	Australian Department of Environment and Energy	06/2016	http://ageis.climatechange.gov.au/QueryAppendixTable.aspx
BM-R1	Population Estimates by Local Government Area (ASGS 2016), 2006 to 2016	Tables 1 to 8	Australian Bureau of Statistics	07/2017	http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3218.02016?OpenDocument
BM-R2	National Postcode Concordances 2020	Table 3	Australian Bureau of Statistics	07/2020	http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1270.0.55.006July%202011?OpenDocument

BM-R3	Economic indicators by region	n/a	Australian Bureau of Statistics	07/1905	http://economic-indicators.id.com.au/?StateId=8
BM-R4	8165.0 Counts of Australian Businesses, including Entries and Exits, Jun 2013 to Jun 2017	Jun-17	Australian Bureau of Statistics	20/02/2018	http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8165.0Jun+2013+to+Jun+2017
BM-R5	2016 Census - Employment, Income and Education - LGA (POW) by OCCP - 1 Digit Level	n/a	Australian Bureau of Statistics	1/01/2018	http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8165.0Jun%202013%20to%20Jun%202017?OpenDocument
BM-R6	Australian Population statistics	ERP by LGA (ASGS 2017), 2001 to 2017	ABS.Stat	2017	http://stat.data.abs.gov.au/Index.aspx?DataSetCode=ABS_ERP_LGA2017
BM-R7	Australian Historical population statistics	3105.0.65.001	Australian Bureau of Statistics	2014	http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3105.0.65.0012014?OpenDocument
BM-R8	Census of Population and Housing, 2016, TableBuilder	Occupied dwellings by LGA	Australian Bureau of Statistics	2016	https://auth.censusdata.abs.gov.au/webapi/jsf/login.xhtml
BM-R9	Census of Population and Housing, 2016, TableBuilder	Dwelling structure by LGA	Australian Bureau of Statistics	2016	https://auth.censusdata.abs.gov.au/webapi/jsf/login.xhtml
BM-R10	Census of Population and Housing, 2016, TableBuilder	Population by sex and LGA	Australian Bureau of Statistics	2016	https://auth.censusdata.abs.gov.au/webapi/jsf/login.xhtml
BM-R11	3218.0 Regional Population Growth, Australia	Population Estimates by Local Government Area (ASGS 2017), 2016 to 2017	Australian Bureau of Statistics	31/08/2018	https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3218.02016-17?OpenDocument
BM-R13	SEIFA 2016 by LGA	n/a	Australian Bureau of Statistics	2016	http://stat.data.abs.gov.au/Index.aspx?DataSetCode=ABS_SEIFA_LGA
BM-R14	National Economic Indicators Series	2015/16 and 2017/18	.idcommunity	2018	https://economic-indicators.id.com.au/?StateId=8&Year=2016
GHG-R1	National Greenhouse Accounts Factors	Table 2	Australian Department of Environment and Energy	07/2021	http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2021
GHG-R2	National Greenhouse Accounts Factors	Table 41	Australian Department of Environment and Energy	07/2021	http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2021

GHG-R3	National Greenhouse Accounts Factors July 2021	Table 17	Australian Department of Environment and Energy	07/2021	http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2021
GHG-R4	National Greenhouse Accounts Factors July 2021	Table 31	Australian Department of Environment and Energy	07/2021	http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2021
GHG-R5	National Greenhouse Accounts Factors July 2021		Australian Department of Environment and Energy	08/2021	https://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-aug-2021
GHG-R6	National Greenhouse Accounts Factors July 2021	Table 44	Australian Department of Environment and Energy	07/2021	http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2021
GHG-R7	National Greenhouse Accounts Factors July 2021	Appendix 1	Australian Department of Environment and Energy	07/2021	http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2021
GHG-R9	National Greenhouse Accounts Factors July 2021	Table 4	Australian Department of Environment and Energy	07/2021	http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2021
GHG-R10	National Greenhouse Accounts Factors July 2021	Tables 1,2 & 3	Australian Department of Environment and Energy	07/2021	http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2021
GHG-R11	2021 Australian energy statistics update	Table O; 2018/19 data	Department of Industry, Innovation and Science	10/2021	https://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Pages/Australian-energy-statistics.aspx#
GHG-R12	Electricity Gas Australia 2015	Table 3.5	Electricity Gas Australia 2015	04/2015	http://www.electricitygasaustralia.com.au/member/loginms/1f8ba11a-63d2-4a4f-a0c1-9b23fff5f8b4
GHG-R13	Derived data	n/a	n/a	n/a	n/a
GHG-R14	National Greenhouse Gas Inventory	n/a	Australian Department of Environment and Energy	06/2021	http://ageis.climatechange.gov.au/#
GHG-R15	National Greenhouse Gas Inventory	n/a	Australian Department of Environment and Energy	06/2021	http://ageis.climatechange.gov.au/#

GHG-R16	National Greenhouse Gas Accounts Factors	Section 2.4.2.8	Australian Department of Environment and Energy	06/2021	http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2021
GHG-R17	National Greenhouse Gas Inventory Activity Tables	Energy	Australian Department of Environment and Energy	06/2021	http://ageis.climatechange.gov.au/QueryAppendixTable.aspx
GHG-R18	2016 SoE Atmosphere carbon dioxide, methane and nitrous oxide emissions by sector, 2015	data link	Australian Government	Jun-18	https://data.gov.au/dataset/2016-soe-atmosphere-carbon-dioxide-methane-and-nitrous-oxide-emissions-by-sector-2015
IP-R1	National Greenhouse Gas Inventory (AGEIS)	Industria Process Emissions by State	Australian Department of Environment and Energy	06/2021	http://ageis.climatechange.gov.au/NGGI.aspx
LU-R1	IBRA7 regions and codes	n/a	Australian Department of Environment and Energy	2015	http://www.environment.gov.au/land/nrs/science/ibra/ibra7-codes
LU-R2	Activity Table 1990-2016 - LULUCF	Table 5	Australian Department of Environment and Energy	2018	http://ageis.climatechange.gov.au/QueryAppendixTable.aspx
LU-R3	IPCC Carbon emissions guidelines 2006	volume 4, chapter 2	IPCC	2013	https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf
PU-R1	National Greenhouse Inventory 2021	n/a	Australian Department of Environment and Energy	06/2021	http://ageis.climatechange.gov.au/
SE-R1	Australia National Waste Report 2016	Table 3.3	Electricity Gas Australia	04/2015	http://www.electricitygasaustralia.com.au/member/loginms/1f8ba11a-63d2-4a4f-a0c1-9b23fff5f8b4
SE-R2	Electricity Gas Australia 2015	Tables 5.1 & 5.3	Electricity Gas Australia	04/2015	http://www.electricitygasaustralia.com.au/member/loginms/1f8ba11a-63d2-4a4f-a0c1-9b23fff5f8b4
SE-R3	Small-scale Technology Certificates - Registered	Table 1	Clean Energy Regulator	03/2022	http://www.cleanenergyregulator.gov.au/RET/Forms-and-resources/postcode-data-for-small-scale-installations
SE-R4	Renewable Energy (Electricity) Regulations 2001	Schedule 5—Zone ratings and zones for solar	Australian Federal Government	06/2001	https://www.legislation.gov.au/Details/F2014C00241/Html/Text#_Toc382818619

		(photovoltaic) systems			
SE-R5	Victorian street/suburb combined listing	n/a	Australian Gas Networks	06/2018	https://www.australiangasnetworks.com.au/our-business/regulatory-information/participant-documentation
SE-R6	Natural Gas Availability Queensland	n/a	Australian Gas Networks	01/2018	https://www.maketheconnection.com.au/_r494/media/system/attrib/image/330/Qld%20Postcodes.pdf
SE-R7	Municipal Energy Profiles activity tool	Summary table	Northern Alliance for Greenhouse Action	06/2015	not available online
SE-R8	Natural Gas Availability South Australia	n/a	Australian Gas Networks	01/2018	https://www.maketheconnection.com.au/_r2427/media/system/attrib/file/630/11974%20SA%20Gas%20Postcodes.pdf
SE-R9	Natural Gas Availability New South Wales	n/a	Australian Gas Networks	01/2018	https://www.maketheconnection.com.au/_r2691/media/system/attrib/file/666/NSW%20Gas%20Postcodes.pdf
SE-R10	Ausgrid average electricity consumption by LGA 2017 pdf	n/a	Ausgrid	Feb-18	https://www.ausgrid.com.au/Industry/Innovation-and-research/Data-to-share/Average-electricity-use
SE-R11	Derived table	n/a	Ironbark	22/03/2019	n/a
SE-R12	Jemena gas consumption data by LGA 2016	n/a	Jemena	2016	https://jemena.com.au/about/document-centre/gas/average-gas-consumption
SE-R13	Natural gas availability	n/a	Jemena	2018	http://www.gonaturalgas.com.au/natural-gas-availability
TR-R1	National Regional Profile - Industry LGA 2010_14	Table 1	Australian Bureau of Statistics	06/2016	http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1379.0.55.0012010-14?OpenDocument
TR-R2	Australian Domestic Airline Activity—time series	Domestic Totals & Top Routes July 2004–July 2018	Department of Infrastructure, Regional Development, and Cities	09/2018	https://bitre.gov.au/publications/ongoing/domestic_airline_activity-time_series.aspx
TR-R3	Volume to weight conversions	n/a	Aqua-Calc	28/09/2018	https://www.aqua-calc.com/calculate/volume-to-weight
TR-R4	Vehicle Usage by Vehicle Type	n/a	NSW Roads and Maritime Services	31/03/2019	https://www.rms.nsw.gov.au/about/corporate-publications/statistics/registrationandlicensing/tables/table112_2019q1.html
TR-R5	Registered Vehicle Totals by LGA	n/a	NSW Roads and Maritime Services	31/03/2019	https://www.rms.nsw.gov.au/about/corporate-publications/statistics/registrationandlicensing/tables/table1111_2017q2.html
TR-R6	Flight carbon emissions calculator	n/a	ICAO	n/a	https://www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx

TR-R7	Fairport activity data	n/a	NSW Transport Services	1/11/2016	https://opendata.transport.nsw.gov.au/dataset/nsw-intrastate-regional-aviation-statistics
TR-R8	Flight destination data	n/a	Flight Radar 24	n/a	www.flightradar24.com/
WS-R1	Waste Generation and Resource Recovery - 2010_11	Pg. 55	Randell Environmental Consulting	02/2014	http://www.environment.gov.au/system/files/resources/4b666638-1103-490e-bdef-480581a38d93/files/wgrra.pdf
WS-R2	Waste Account, Australia, Experimental Estimates 2013	Table 1	Australian Bureau of Statistics	02/2013	http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4602.0.55.0052013?OpenDocument
WS-R3	National Greenhouse Inventory	n/a	Australian Department of Environment and Energy	06/2021	http://ageis.climatechange.gov.au/
WS-R4	NGERS determination 2008	5.11	Australian Department of Environment and Energy	06/2017	https://www.legislation.gov.au/Details/F2018C00431
WS-R5	NGERS determination 2008	5.14	Australian Department of Environment and Energy	06/2017	https://www.legislation.gov.au/Details/F2018C00431
WS-R6	NGERS determination 2008	5.14A	Australian Department of Environment and Energy	06/2017	https://www.legislation.gov.au/Details/F2018C00431
WS-R7	NGERS determination 2008	Division 5.2.2—Method 1—emissions of methane released from landfills	Australian Department of Environment and Energy	06/2017	https://www.legislation.gov.au/Details/F2018C00431
WS-R8	Australia National Waste Report 2021	n/a	Randall Environment Consulting	06/2021	https://www.environment.gov.au/system/files/resources/d075c9bc-45b3-4ac0-a8f2-6494c7d1fa0d/files/national-waste-report-2016.pdf
WS-R9	National Greenhouse Gas Inventory	n/a	Australian Department of Environment and Energy	06/2021	http://ageis.climatechange.gov.au/#

9. Appendix IV: Industry Classifications and Categorisations

Australia Energy Statistics Categories		
Sector	Subsector	Lookup ID
Div. A Agriculture, forestry and fishing	n/a	1
Div. B Mining	n/a	2
Div. B Mining	06 Coal mining	2b
Div. B Mining	07 Oil and gas extraction	2c
Div. B Mining	08-10 Other mining	2f
Div. C Manufacturing	n/a	3
Div. C Manufacturing	11-12 Food, beverages and tobacco	3q
Div. C Manufacturing	13 Textile, clothing, footwear and leather	3d
Div. C Manufacturing	Wood, paper and printing	3r
Div. C Manufacturing	14 Wood and wood products	3e
Div. C Manufacturing	15-16 Pulp, paper and printing	3s
Div. C Manufacturing	*1701 Petroleum refining*	3h
Div. C Manufacturing	*1709 Other petroleum and coal product manufacturing*	3h
Div. C Manufacturing	18-19 Basic Chemical and Chemical, Polymer and Rubber Product Manufacturing	3t
Div. C Manufacturing	20 Non-metallic mineral products	3k
Div. C Manufacturing	*201 Glass and glass products*	n/a
Div. C Manufacturing	*202 Ceramics*	n/a
Div. C Manufacturing	*203 Cement, lime, plaster and concrete*	n/a
Div. C Manufacturing	*209 Other non-metallic mineral products*	n/a
Div. C Manufacturing	*211-212 Iron and steel*	n/a
Div. C Manufacturing	*213-214 Basic non-ferrous metals*	n/a
Div. C Manufacturing	22 Fabricated metal products	3m
Div. C Manufacturing	23-24 Machinery and equipment	3o
Div. C Manufacturing	25 Furniture and other manufacturing	3p
Div. D Electricity, Gas, Water & Waste Services	n/a	4
Div. D Electricity, Gas, Water & Waste Services	26 Electricity supply	4b
Div. D Electricity, Gas, Water & Waste Services	27 Gas supply	4c
Div. D Electricity, Gas, Water & Waste Services	28-29 Water supply, sewerage and drainage services	4d

Div. E Construction	n/a	5
Commercial	n/a	24
Div. I Transport, postal & warehousing	n/a	9
Div. I Transport, postal & warehousing	46 Road transport	9b
Div. I Transport, postal & warehousing	47 Rail transport	9c
Div. I Transport, postal & warehousing	48 Water transport	9d
Div. I Transport, postal & warehousing	48 Water transport - international	n/a
Div. I Transport, postal & warehousing	48 Water transport - coastal	9d
Div. I Transport, postal & warehousing	49 Air transport	9e
Div. I Transport, postal & warehousing	49 Air transport - domestic	9e
Div. I Transport, postal & warehousing	49 Air transport - international	n/a
Div. I Transport, postal & warehousing	50-53 Other transport, services and storage	9j
Residential	n/a	25
Solvents, lubricants, greases and bitumen	n/a	n/a
Total	n/a	

ABS Employment Categories		
Cat 1	Level	ID
Agriculture, Forestry and Fishing	1	1
Agriculture, Forestry and Fishing, nfd	2	1a
Agriculture	2	1b
Aquaculture	2	1c
Forestry and Logging	2	1d
Fishing, Hunting and Trapping	2	1e
Agriculture, Forestry and Fishing Support Services	2	1f
Mining	1	2
Mining, nfd	2	2a
Coal Mining	2	2b
Oil and Gas Extraction	2	2c
Metal Ore Mining	2	2d
Non-Metallic Mineral Mining and Quarrying	2	2e
Exploration and Other Mining Support Services	2	2f
Other mining	3	2g
Manufacturing	1	3
Manufacturing, nfd	2	3a
Food Product Manufacturing	2	3b

Beverage and Tobacco Product Manufacturing	2	3c
Textile, Leather, Clothing and Footwear Manufacturing	2	3d
Wood Product Manufacturing	2	3e
Pulp, Paper and Converted Paper Product Manufacturing	2	3f
Printing (including the Reproduction of Recorded Media)	2	3g
Petroleum and Coal Product Manufacturing	2	3h
Basic Chemical and Chemical Product Manufacturing	2	3i
Polymer Product and Rubber Product Manufacturing	2	3j
Non-Metallic Mineral Product Manufacturing	2	3k
Primary Metal and Metal Product Manufacturing	2	3l
Fabricated Metal Product Manufacturing	2	3m
Transport Equipment Manufacturing	2	3n
Machinery and Equipment Manufacturing	2	3o
Furniture and Other Manufacturing	2	3p
Food, beverages and tobacco	3	3q
Electricity, Gas, Water and Waste Services	1	4
Electricity, Gas, Water and Waste Services, nfd	2	4a
Electricity Supply	2	4b
Gas Supply	2	4c
Water Supply, Sewerage and Drainage Services	2	4d
Waste Collection, Treatment and Disposal Services	2	4e
Construction	1	5
Construction, nfd	2	5a
Building Construction	2	5b
Heavy and Civil Engineering Construction	2	5c
Construction Services	2	5d
Wholesale Trade	1	6
Wholesale Trade, nfd	2	6a
Basic Material Wholesaling	2	6b
Machinery and Equipment Wholesaling	2	6c
Motor Vehicle and Motor Vehicle Parts Wholesaling	2	6d
Grocery, Liquor and Tobacco Product Wholesaling	2	6e
Other Goods Wholesaling	2	6f
Commission-Based Wholesaling	2	6g

Retail Trade	1	7
Retail Trade, nfd	2	7a
Motor Vehicle and Motor Vehicle Parts Retailing	2	7b
Fuel Retailing	2	7c
Food Retailing	2	7d
Other Store-Based Retailing	2	7e
Non-Store Retailing and Retail Commission-Based Buying and/or Selling	2	7f
Accommodation and Food Services	1	8
Accommodation and Food Services, nfd	2	8a
Accommodation	2	8b
Food and Beverage Services	2	8c
Transport, Postal and Warehousing	1	9
Transport, Postal and Warehousing, nfd	2	9a
Road Transport	2	9b
Rail Transport	2	9c
Water Transport	2	9d
Air and Space Transport	2	9e
Other Transport	2	9f
Postal and Courier Pick-up and Delivery Services	2	9g
Transport Support Services	2	9h
Warehousing and Storage Services	2	9i
Information Media and Telecommunications	1	10
Information Media and Telecommunications, nfd	2	10a
Publishing (except Internet and Music Publishing)	2	10b
Motion Picture and Sound Recording Activities	2	10c
Broadcasting (except Internet)	2	10d
Internet Publishing and Broadcasting	2	10e
Telecommunications Services	2	10f
Internet Service Providers, Web Search Portals and Data Processing Services	2	10g
Library and Other Information Services	2	10h
Financial and Insurance Services	1	11
Financial and Insurance Services, nfd	2	11a
Finance	2	11b
Insurance and Superannuation Funds	2	11c
Auxiliary Finance and Insurance Services	2	11d
Rental, Hiring and Real Estate Services	1	12
Rental, Hiring and Real Estate Services, nfd	2	12a

Rental and Hiring Services (except Real Estate)	2	12b
Property Operators and Real Estate Services	2	12c
Professional, Scientific and Technical Services	1	13
Professional, Scientific and Technical Services, nfd	2	13a
Professional, Scientific and Technical Services (except Computer System Design and Related Services)	2	13b
Computer System Design and Related Services	2	13c
Administrative and Support Services	1	14
Administrative and Support Services, nfd	2	14a
Administrative Services	2	14b
Building Cleaning, Pest Control and Other Support Services	2	14c
Public Administration and Safety	1	15
Public Administration and Safety, nfd	2	15a
Public Administration	2	15b
Defence	2	15c
Public Order, Safety and Regulatory Services	2	15d
Education and Training	1	16
Education and Training, nfd	2	16a
Preschool and School Education	2	16b
Tertiary Education	2	16c
Adult, Community and Other Education	2	16d
Health Care and Social Assistance	1	17
Health Care and Social Assistance, nfd	2	17a
Hospitals	2	17b
Medical and Other Health Care Services	2	17c
Residential Care Services	2	17d
Social Assistance Services	2	17e
Arts and Recreation Services	1	18
Arts and Recreation Services, nfd	2	18a
Heritage Activities	2	18b
Creative and Performing Arts Activities	2	18c
Sports and Recreation Activities	2	18d
Gambling Activities	2	18e
Other Services	1	19
Other Services, nfd	2	19a
Repair and Maintenance	2	19b
Personal and Other Services	2	19c

Private Households Employing Staff and Undifferentiated Goods and Service-Producing Activities of Households for Own Use	2	19d
Inadequately described	1	20
Not stated	1	21
Not applicable	1	22
Total	1	23
Commercial	3	24
Residential	3	25

Hybrid categories		
Category	Combined categories	ID
Other mining	2a	2g
	2d	
	2e	
Food, beverages and tobacco	3b	3q
	3c	
Wood, paper and printing	3e	3r
	3f	
	3g	
15-16 Pulp, paper and printing	3f	3s
	3g	
18-19 Basic Chemical and Chemical, Polymer and Rubber Product Manufacturing	3i	3t
	3j	
Other transport, services, and storage	9f	9j
	9g	
	9h	
	9i	

Code	Category
1	Agricultural
2	IE
2b	Industrial
2c	Industrial
2f	Industrial
3	IE
3q	Industrial
3d	Industrial
3r	Not recorded

3e	Industrial
3s	Industrial
3h	Not recorded
3t	Not recorded
3k	Industrial
n/a	Not recorded
3m	Not recorded
3o	Industrial
3p	Not recorded
4	IE
4b	Industrial
4c	Industrial
4d	Industrial
5	Industrial
24	Commercial
9	Industrial
9b	IE
9c	IE
9d	Not recorded
9e	Not recorded
9j	IE
25	Residential