Snapshot Municipal Carbon Emissions

Calculation Methods

Applies to Activity Tool version: 7m

Table of Contents

List of Tables

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 1
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

There are six methods that can be applied, depending on the availability of data. Methods SE1.2 and SE1.3 are largely identical but take into account possible variations in the provision of data from suppliers. SE1.6 uses publicly available municipal-level data from AUSGRID for selected NSW municipalities from 2017. If supplier data is not available, SE1.1, SE1.4 and SE1.5 derive municipal emissions from scaled state-level data. The results of the three models should be compared – for most municipalities SE1.5 is expected to give the most accurate results, followed by SE1.4 and SE1.1.

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: Consumption data from distributor

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

[1] See appendix II for regressions

Sector	Estimation method
	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.
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. 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.
Industrial	The regression 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. Secondary scaling done using the ratio of energy density in data year compared to inventory year, as predicted by *SE-REG4.*
Commercial	Firstly, scaled by *commercial employment growth rate*[3] for municipality. Secondary scaling done using the ratio of energy density in data year compared to inventory year, as predicted by *SE-REG5.*
Industrial	Firstly, scaled by *industrial employment growth rate*[4] for municipality. Secondary scaling done using the ratio of energy density in data year compared to inventory year, as predicted by *SE-REG5.*

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 *industrial 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.
- This method 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.

2.2 SE2: Stationary Energy – Grid Supplied Gas

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

Table 6: 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 7: 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 8: 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:

[7] See regressions calculations in Appendix II

Table 9: SE1.4 – Temporal scaling methods

Sector	Temporal scaling method
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

Data requirements

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

[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

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 TR1: On Road Transport

3.1.1 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 10: 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 11: 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

3.2 TR2: Aviation Travel

Aviation travel emissions are associated with flights within the municipality.

Table 12: TR2 - Methods

Method	Data quality			Key data requirement
	Data Quality	Activity data	Emissions factors	
TR2.1	High	Detailed Activity Data	More general emission factors	Using national aviation data ascribed to airports

3.2.1 Method TR2.1: Emissions data for passenger aviation travel

This method scales emissions associated from passenger travel on the main commercial air carriers. This data is aggregated through the

This method uses the following data:

- fuel consumption by airport

Table 13: TR2.2 – Base data source

Data description	Granularity	Source	Source ID
Passenger activity data	Airport level	BITRE	TR-R2

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 14: 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

Airport code	Name	State	LGA
EMD	Emerald	Queensland	Central Highlands
GLT	Gladstone	Queensland	Gladstone
ISA	Mount Isa	Queensland	Mount Isa
MKY	Mackay	Queensland	Mackay
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:

Table 15: 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

Airport 1	Airport 2	Total trips	Average passenger	Aircraft fuel burn - kerosene (kg)	Total passengers CO2e/journey
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
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

Airport 1	Airport 2	Total trips	Average passenger	Aircraft fuel burn - kerosene (kg)	Total passengers CO2e/journey
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
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

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

Kerosene: Scaled by population growth

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 16: 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 17: 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.

Total emissions for			
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 18: 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[11]:

Table 19: Fermentation Emissions Factors

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 20: 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:

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

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]:

Manure management emissions factors			
Category	**Emissions Factor (kg CO2e/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.

5.3 AG3: Agricultural Soils

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

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 21: AG3 - Methods

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

5.4 LU1: Land Clearing

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

Table 22: 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

5.4.1 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 23: 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[13]

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

[13] 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[14]

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:

[14] 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.

5.5 LU2: Afforestation

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

Table 24: 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

5.5.1 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 25: LU1.1 – 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 26: 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 27: 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 28: 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 - 2015-16	n/a	Australian Bureau of Statistics	2016	https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/7121.02015-16?OpenDocument
AG-R7	National Greenhouse Inventory 2016	n/a	Australian Department of Environment and Energy	06/2016	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 2017	Table 3	Australian Bureau of Statistics	07/2017	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	Australian Bureau of Statistics	31/08/2018	https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3218.02016-17?OpenDocument

		Government Area (ASGS 2017), 2016 to 2017			
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 July 2018	Table 2	Australian Department of Environment and Energy	07/2018	http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2018
GHG-R2	National Greenhouse Accounts Factors July 2018	Table 41	Australian Department of Environment and Energy	07/2018	http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2018
GHG-R3	National Greenhouse Accounts Factors July 2018	Table 17	Australian Department of Environment and Energy	07/2018	http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2018
GHG-R4	National Greenhouse Accounts Factors July 2018	Table 31	Australian Department of Environment and Energy	07/2018	http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2018
GHG-R5	National Greenhouse Accounts Factors July 2015		Australian Department of Environment and Energy	08/2015	https://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-aug-2015
GHG-R6	National Greenhouse Accounts Factors July 2018	Table 44	Australian Department of Environment and Energy	07/2018	http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2018
GHG-R7	National Greenhouse Accounts Factors July 2018	Appendix 1	Australian Department of Environment and Energy	07/2018	http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2018
GHG-R9	National Greenhouse Accounts Factors July 2018	Table 4	Australian Department of Environment and Energy	07/2018	http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2018
GHG-R10	National Greenhouse Accounts Factors July 2017	Tables 1,2 & 3	Australian Department of Environment and Energy	07/2017	http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2017

GHG-R11	2016 Australian energy statistics update	Table O; 2013/14 data	Department of Industry, Innovation and Science	10/2016	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	06/2014	http://ageis.climatechange.gov.au/#
GHG-R15	National Greenhouse Gas Inventory	n/a	Australian Department of Environment and Energy	06/2014	http://ageis.climatechange.gov.au/#
GHG-R16	National Greenhouse Gas Accounts Factors	Section 2.4.2.8	Australian Department of Environment and Energy	06/2017	http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2017
GHG-R17	National Greenhouse Gas Inventory Activity Tables	Energy	Australian Department of Environment and Energy	Jun-18	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	06/2016	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	2006	https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf

PU-R1	National Greenhouse Inventory 2016	n/a	Australian Department of Environment and Energy	06/2016	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	09/2016	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 (photovoltaic) systems	Australian Federal Government	06/2001	https://www.legislation.gov.au/Details/F2014C00241/Html/Text#_Toc382818619
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
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 2016	n/a	Australian Department of Environment and Energy	06/2016	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	Australian Department of	06/2017	https://www.legislation.gov.au/Details/F2018C00431

		of methane released from landfills	Environment and Energy		
WS-R8	Australia National Waste Report 2016	n/a	Randall Environment Consulting	06/2017	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	06/2019	http://ageis.climatechange.gov.au/#