Snapshot Methodology 2022/23 Release v1a

snapshot

COMMUNITY CLIMATE TOOL

Prepared for
Snapshot

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V1a	Ironbark Sustainability	20/12/2022	First Release

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About Ironbark Sustainability
For nearly two decades, Ironbark Sustainability has worked with councils and their communities to reduce greenhouse emissions, tackle climate change and implement sustainability projects and programs. We bring together a wealth of technical and financial analysis, maintenance and implementation experience in the areas of building energy and water efficiency, climate action and strategy development, public lighting and data management. We pride ourselves on supporting our clients to achieve real action on sustainability.

Our Mission
The Ironbark mission is to achieve real action on sustainability for councils and their communities.

Ironbark is a certified B Corporation. We have been independently assessed as meeting the highest standards of verified social and environmental performance, public transparency, and legal accountability to balance profit and purpose.

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1. Introduction

> *A city's ability to take effective action on mitigating climate change, and monitor progress, depends on having access to good quality data. Planning for climate action begins with developing a GHG inventory.*
>
> Global Protocol for Community-Scale Greenhouse Gas Inventories v1.1 (p9)

The Snapshot Climate portal has been developed by Ironbark Sustainability and Beyond Zero Emissions to give councils and communities free access to high quality community emissions data to support climate action planning.

Snapshot is the first national tool with data for every region in Australia. We use a common framework to allow for comparison between municipalities and regions. All the municipal profiles add up to the national emissions total, meaning that no emissions go unaccounted for.

Snapshot was founded on the principle of transparency. One of the core objectives of the tool is to increase community and council capacity to understand and use community emissions data. For this reason, the full methodology including calculations, data sources and emissions factors is freely available in this document.

1.1 Verification

Snapshot has been developed with input from Australia's leading experts and based on decades of experience working with hundreds of councils and community groups throughout Australia. Through ongoing engagement with key stakeholders and industry experts the Snapshot data, methodology and calculations have been independently verified as aligned with the GPC and with best practice industry standards for community emissions profile development in Australia.

The development of community emissions profiles is complex and there are many different approaches which can be considered to be aligned with the GPC and in line best practice. All verification has been undertaken in good faith to support council and community access to high quality community emissions profiles and to increase community emissions literacy and climate action planning capacity within the sector.

For more information please contact hello@snapshotclimate.com.au

2. How to use this document

This document outlines the methods employed for calculating emissions for municipalities as used by the Snapshot Climate portal.

The methods outlined in this document have been developed and shared with the following objectives:

- 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 municipalities 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.

2.1 Navigation

2.1.1 Methods by sector

The document is structured sector by sector, so each segment of the donut has an accompanying methodology. For each sector you will find:

- The approach – this is the elevator pitch and gives a brief overview of the method and sources used and any notable exclusions for each emissions source.
- The detail – for each sector the data sources, emissions factors, and calculation method are provided to give a full understanding of how the numbers were arrived at and to enable independent use of the data.

2.1.2 Methods by state and year

In some cases, different methods have been used for different states or reporting years. The availability of data can vary between states and over time. To ensure best practice across all profiles it is therefore necessary in these cases to use different data sets and methods. Table 44: Methodology overview by state in the Appendix lists the methods state by state so you can easily understand which method applies to your profile.

2.1.3 Naming conventions for methods

From the 2022/23 release a new naming convention for methods has been introduced which has been established by Ironbark, based on the emissions sectors, subsectors and data tiers outlined in the GPC. Within the Methodology document each of the methods outlined in this document has a corresponding method reference code. 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.

Table 1: Naming conventions explainer

Method Reference	Sector	Subsector	Data Tier	Method version No.
SEE_RE_T1_V1	Stationary Energy Electricity	Residential	Tier 1	1st version of the method released
	SEE	RE	TI	V1
TR_AV_T2_V2	Transport	Aviation	Tier 2	2nd version of the method released
	TR	A	T2	V2

As a user it is important to:

- Understand which methods have been used to develop the profiles for different municipalities
- Understand that different methods may have been used to develop previous versions of the profile for your municipality
- Take the impact of different methods into consideration when comparing profiles

For example, if your 2018 profile uses SEE_RE_T1_V1 and the profile of a neighbouring municipality uses SEE_RE_T1_V2 it is important to understand you are not comparing apples with apples. Alternatively, as part of the latest update the electricity emissions for all profiles have been backdated across all years to incorporate improvements to data and methods. So, if you have a 2018 profile downloaded in 2019, this will differ from the 2018 profile currently on the portal. The naming convention can help you keep track of improvements to the methods used for your municipality's profile over time.

The previous Snapshot Methodology 2019-2021 will remain available for download from the Resources page of the Snapshot portal so that the methods and sources of any historical profiles are still accessible. When doing any communications work comparing Snapshot profiles, you can include the naming convention for the method and reference to the appropriate Methodology document to help maintain clarity and transparency. Where a method was developed and superseded before the release of Snapshot, it has not been detailed in the available Methods documents to avoid confusion.

2.1.4 Data sources and emissions factors

Data sources have a Source ID which is referenced under the relevant methods sector under the Base Data section. The full source reference can then be looked up in the References section using the Source ID code.

All emissions factors used are listed in the Appendix with the relevant table number provided in the Emissions Factors section for each sector. In some cases, a specific emissions factor will not available, for example if the source data used has already been converted into emissions. In these cases, the reason for not providing an emissions factor will be outlined.

2.1.5 Regressions

Regressions are formula which establish a relationship between two sets of data and are used within many of the methods detailed in this document. Where a regression formula has been used, this will be detailed within the Method section for the sector so the calculation can be replicated.

2.2 Improving methods over time

The value of community emissions profiles in climate action planning is becoming increasingly apparent. This is resulting in significant improvements in the availability of activity data at the community scale (such as commercial electricity consumption or km travelled by bus). This is great news for the climate action sector.

Snapshot is always aiming to represent best practice in community emissions profiles. In order to maintain this standard, it is essential that we update our approach to incorporate the best available data sources and methods as they become available.

2.2.1 Changes to historical profiles

Where possible we will update historical profiles using new improved data and methods to enable comparison between different years. This also ensures that all Snapshot profiles on the portal are consistent in their methods and represent best practice.

For this reason, you may find that the current Snapshot profiles on the portal differ from versions you have downloaded previously. Cross referencing the naming convention outlined in Section 2.1.3 with the relevant Snapshot Methodology document (available from the Resources page of the portal) will help you understand which methods have been used for different profiles.

While changes to historical profiles may present a challenge in terms of communicating these differences, it is important to note that methods are always changed to improve accuracy and reliability. So, where a historical profile has been updated with a new method, you can assume the outcome is a more accurate and reliable profile. For tips on how to communicate these changes please visit the FAQs page of the Snapshot Climate portal.

2.2.2 Differences in methods between other municipalities

In some cases, certain data sets will not be available for all municipalities. For example, Google EIE transport data is only available for municipalities which have a total volume of travel over a set threshold. In these cases, it is important to understand that the limitations of comparing emissions totals developed using different data sources and methods. Table 44: Methodology overview by statecan be used to understand which methods have been used in different municipalities.

2.2.3 Independently developed profiles

Some councils have developed their own profiles independently. Where the publication of multiple different profiles such as within Council's climate strategy and on Snapshot, is likely to cause confusion for the community, Council may request that their independently developed profile be uploaded to Snapshot in place of the standard profile. In these cases, this will be stated on the profile as displayed on the portal and you will need to contact the council directly to get more information on the method employed.

2.3 Citation

We encourage you to reference the Methodology when using it within your work to support transparency across the sector. Where you wish to reference the methodology please use the following citation:

Ironbark Sustainability. (2022, November). Snapshot Methodology 2022. Snapshot Climate. https://snapshotclimate.com.au/resources/

For formal reporting purposes such as reporting to CDP Cities as part of GCOM, you can attach the full PDF of this document as a reference for the methodology used.

2.4 Questions and feedback

If you have any questions around the Snapshot methodology, calculations or data sources that are not answered in this document, or if you have any feedback or suggestions you would like to share please feel free to email us your query at hello@snapshotclimate.com.au.

2.5 Disclaimer

Snapshot profiles have been developed in accordance with the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) by experts certified under the City Climate Planner Certificate Program.

The GPC is designed to promote best practice greenhouse gas (GHG) accounting and reporting and was developed through an inclusive multi-stakeholder process. This involved input from experts from nongovernmental organisations, governments, and others convened by WRI, C40 and ICLEI. The methodology used to develop Snapshot profiles has been developed in good faith and BZE and Ironbark do not undertake any duty to or accept any responsibility to any third party who may rely upon this document.

Data has been sourced from a variety of third parties (such as Distribution Network Service Providers (DNSPs) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). While every effort has been made to use data from reputable sources and a thorough quality assurance process undertaken, neither Snapshot users nor Snapshot are responsible for data inaccuracies by third parties.

3. Overview of emissions reported

3.1 The Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC)

The Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC) was developed by the World Resources Institute, C40 Cities and ICLEI to respond to the challenge of inconsistency in municipal scale emissions reporting. The GPC offers a robust and clear framework that builds on existing methodologies for calculating and reporting municipal GHG emissions. It is the most credible municipal scale reporting framework and is used worldwide.

All Snapshot profiles, both historical and current, have been developed in line with the GPC. The GPC takes into consideration the vast variations in the type and quality of data available and provides practitioners with flexibility in terms of acceptable calculation methods and data sources. This allows for changes to be made to the methods and data used while remaining aligned with the GPC; this flexibility is critical to enabling improvement. Where possible this document will use language around methods and data that is consistent with the GPC to allow for easy cross referencing.

3.2 BASIC+

The GPC gives the option of selecting between two reporting levels: BASIC or BASIC+. From the 2022/23 release, Snapshot profiles are aligned with BASIC+ reporting as outlined in the GPC (Global Protocol for Community-Scale Greenhouse Gas Inventories v1.1, p13). Prior to the 2022/23 release, Snapshot profiles met the requirements for BASIC report plus agriculture and land use, and scope 3 stationary energy emissions.

> *The BASIC level covers scope 1 and scope 2 emissions from stationary energy and transportation, as well as scope 1 and scope 3 emissions from waste.*
>
> *BASIC+ involves additional data collection and calculation processes, requiring emissions from IPPU, emissions and removals from AFOLU, scope 3 emissions from stationary energy, and emissions from transboundary transportation.*
>
> Global Protocol for Community-Scale Greenhouse Gas Inventories v1.1 (p12)

3.3 Tiers of data

To improve understanding of the data that has been used for these methods, a tiering structure has been employed based on the system used by the International Panel for Climate Change and referred to within the GPC. 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).

Example: Residential electricity emissions for Victorian municipalities is calculated by scaling state level energy consumption data to the municipal level based on the population, dwelling type and SEIFA rating of the municipality. Conversion factors used are sourced from the National Greenhouse Accounts Factors.

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

Example: Transport emissions for municipalities with Google EIE transport data are calculated based on actual journey distance travelled per year by each transport mode (car, train, bus, tram). Conversion factors used are sourced from the National Greenhouse Accounts Factors.

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

Example: For municipalities where there is a landfill site within the municipal boundary, and where data is available, emissions for Solid Waste could be calculated using site specific waste weights and emissions factors. This is not currently the case for Snapshot as this data is not consistently available.

Tier 1 data is suitable for determining key emissions sources and sectors, and for understanding the scale of emissions within your municipality. However, because it is modelled, Tier 1 data should not be used for tracking emissions over time. While some high-level trends such as the decarbonisation of the electricity grid may be visible in modelled data, it is likely that trends observed will be the result of changes to the variables used in modelling such as population, rather than direct changes to emissions.

Where Tier 2 or Tier 3 data can be sourced which meets the GPC requirements of completeness and reliability, this is preferred. Emissions calculated using activity data sourced for within the specific municipal boundary will be more accurate and will be able to be used for more detailed tracking of trends in emissions over time. At present, most sectors of emissions that are included within Snapshot are Tier 2. For an overview of data tiers used for each sector and state please see Table 3.

3.4 Scopes

Snapshot profiles have been prepared to comply with the GPC's BASIC+ level of GHG accounting. In line with the requirements of GPC BASIC+ compliance, the scopes listed in Table 2 have been included within Snapshot. Emissions are further defined by gas type as either carbon dioxide (CO_2), methane (CH_4) or nitrous oxide (N_2O) and then converted into carbon dioxide equivalent (CO_2-e) for comparison and to measure total impact.

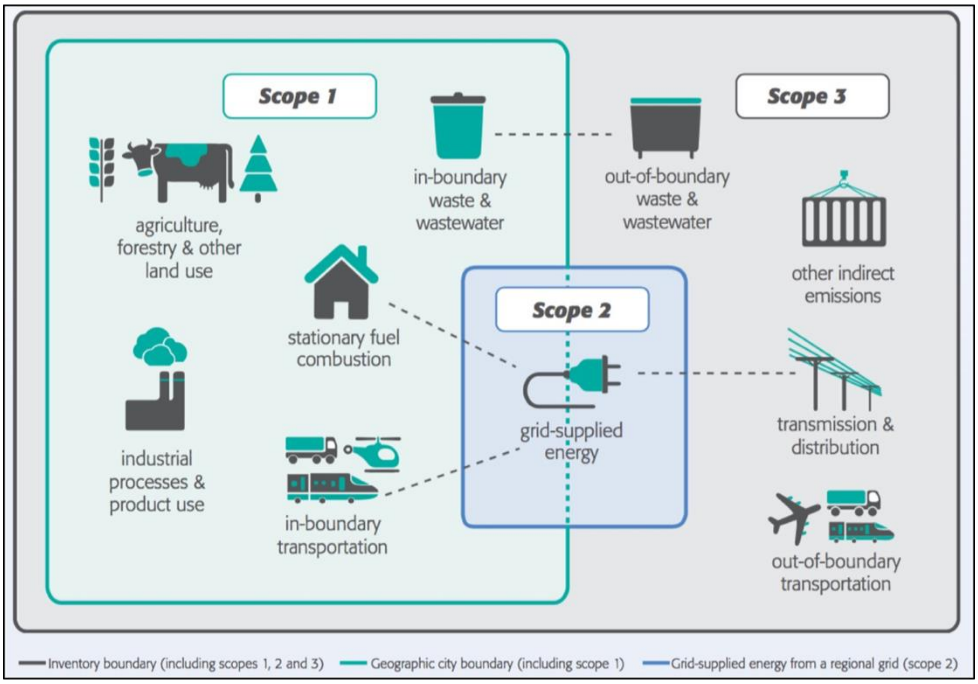

Figure 1: GPC Reporting Boundaries

Table 2: Scopes included by emissions source

Sector	Scopes included
Electricity	Scope 2 emissions from electricity consumption for stationary energy sources Scope 3 emissions from the transmission and distribution of electricity stationary energy sources
Gas	Scope 1 emissions from stationary energy sources (excluding energy production supplied to the grid) Scope 3 emissions from the transmission and distribution of gas stationary energy sources
Transport	Scope 1 emissions from transportation fuel sources Scope 2 emissions from transportation electricity sources Scope 3 emissions from intra boundary transportation Scope 3 emissions from the transmission and distribution of transportation energy sources

Waste	Scope 1 emissions from waste sources (excluding emissions from imported waste) Scope 3 emissions from waste generated within the boundary and exported for treatment
Agriculture and Land Use	Scope 1 emissions from livestock, land and aggregate sources located within the boundary.
IPPU	Scope 1 emissions from industrial processes and product use sources located within the boundary.

3.5 Emissions factors

The majority of emissions factors used in Snapshot are sourced from the National Greenhouse Accounts Factors: 2021[1]. This ensures consistency with Australia's National Greenhouse Accounts and other community scale profiles being developed within Australia. The emissions factors used within calculations for each sector can be found within the relevant sector section and are listed in Appendix B – Emissions Factor Lookup Tables.

3.6 Included categories

There are several categories of emissions that are not included in these methods. There are various reasons for not including these categories such as lack of availability of data. In most instances, the emissions associated with these categories are included in the profile within another category, where this is the case it will be noted in Table 3. As Snapshot and the data that drives it continues to improve, these categories will have individual methods developed.

[1] National Greenhouse Accounts Factors: 2021: https://www.industry.gov.au/data-and-publications/national-greenhouse-accounts-factors-2021

Table 3: Emissions category tiers and inclusions

Category	Tier/Inclusion
Stationary Energy – Grid-Supplied Electricity	Tier 1 and Tier 2
Stationary Energy – Gas	Tier 1 and Tier 2
Stationary Energy – Fugitive Emissions	Not included
Stationary Energy – Additional Networked Energy	Not included
Transport – On Road	Tier 1 and Tier 2
Transport – Aviation	Tier 2
Transport – Water	Included in On Road (for diesel)
Transport – Off Road	Included in On Road
Transport – Trains	Tier 2, Tier 1 included in Stationary Energy
Transport – Buses	Tier 2, Tier 1 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 1
Land Use and Land Use Change – Grassland to Forestland	Tier 1
Land Use and Land Use Change – Forestland to Cropland	Tier 1
Land Use and Land Use Change – Bushfire	Not included
Industrial Processes	Tier 1 and Tier 2
Industrial Product Use – Refrigerants	Tier 1
Industrial Product Use – Other Products	Not included

4. Stationary Energy - Electricity

Stationary energy, specifically electricity, refers to electricity consumed at stationary locations, which largely means buildings. It includes electricity consumed by the residential, commercial and industrial sectors.

4.1 Electricity Residential

4.1.1 Approach

Residential electricity is modelled using a combination of Tier 2 local activity data and state level activity data which is apportioned to municipalities using relevant scaling factors based on residential characteristics such as population and households. This blended approach ensures residential electricity emissions are complete whilst also enabling Tier 2 activity data to be utilised where available.

Tier 2 activity data is available for certain NSW municipalities and all QLD municipalities. All other municipalities use modelled state level data.

4.1.2 Included Categories

Residential electricity includes:

- Scope 2 emissions from electricity consumption for stationary energy sources.
- Scope 3 emissions from the transmission and distribution of electricity stationary energy sources.

4.1.3 Base Data

Table 4: Base Data for Residential Electricity

Availability	Description	Granularity	Source	Source ID
QLD	QLD electricity municipality activity data by sector	Municipality	Energex	SE-R1
NSW	NSW electricity municipality activity data by sector	Municipality	Ausgrid	SE-R2
National	State level stationary energy activity data by sector	State	Australian Energy Statistics	SE-R3
National	Population	Municipality	Australian Bureau of Statistics	BMS-R1
National	DWTD Dwelling type - Total	Municipality	Australian Bureau of Statistics	BMS-R2
National	SEIFA	Municipality	Australian Bureau of Statistics	BMS-R3

4.1.4 Emissions Factors

This section using the grid electricity emissions factors which are provided in Table 45 in the Appendix.

4.1.5 Method SEE_RE_T2_V1 – Local Activity Data

Tier 2 residential electricity activity data is available from Ausgrid (NSW) and Energex (QLD) and is available for 32 municipalities in NSW out of a possible 128 and all QLD municipalities. Table 5 shows which NSW municipalities have tier 2 residential electricity activity data.

Table 5: NSW Municipalities with Tier 2 Residential Electricity Activity Data

Municipality	Municipality	Municipality
Bayside, NSW	Ku-ring-gai, NSW	Randwick, NSW
Burwood, NSW	Lake Macquarie, NSW	Ryde, NSW
Canada Bay, NSW	Lane Cove, NSW	Singleton, NSW
Canterbury-Bankstown, NSW	Maitland, NSW	Strathfield, NSW
Central Coast, NSW	Mosman, NSW	Sutherland Shire, NSW
Cessnock, NSW	Muswellbrook, NSW	Sydney, NSW
Cumberland, NSW	Newcastle, NSW	Upper Hunter Shire, NSW
Georges River, NSW	North Sydney, NSW	Waverly, NSW
Hornsby, NSW	Northern Beaches, NSW	Willoughby, NSW
Hunters Hill, NSW	Parramatta, NSW	Woolahra, NSW
Inner West, NSW	Port Stephens, NSW	

Emissions are derived by integrating the activity data alongside the emissions factors and conversion factors. Equation 1 shows the results.

Equation 1: Tier 2 Residential Electricity Emissions

$$Emissions_{i,j,k} = \sum_{l=2,3} \left(AD_{i,j,k} \times EF_l \times C \right)$$

Where:

$Emissions_{i,j,k}$ is the residential electricity emissions for municipality *i* within state *j* in year *k*

$AD_{i,j,k}$ is the tier 2 residential electricity activity data for municipality *i* within state *j* in year *k*

EF_l is the emissions factor for scope *l*
C is 0.001 which is the conversion factor

4.1.6 Method SEE_RE_T1_V1 – Modelled Data

For municipalities without Tier 2 residential electricity activity data available a modelled approach is required. Municipalities without tier 2 residential electricity activity data currently include all municipalities in VIC, SA, WA, NT and TAS as well as 96 municipalities in NSW.

A regression model is used to estimate residential electricity activity data for municipalities without tier 2 activity data based the municipalities with tier 2 activity data across all reporting periods. Since residential electricity activity is largely driven by population the dependant variable is electricity per capita and the independent variables incorporate various combinations of socio-economic index (SEIFA), population, households and land size. Log transformations are applied to ensure normality. Equation 2 shows the model formulation.

Equation 2: Regression Model for Residential Electricity Activity Data

$$CON\_PC_{i,j,k} = \beta_0 + \beta_1 LOG\left(1/\frac{SEIFA_{i,j,k}}{100}\right) + \beta_2 POP\_HOU_{i,j,k} + \beta_3 ARE\_POP_{i,j,k} + \beta_4 ARE\_HOU_{i,j,k}$$

Where

$CON\_PC_{i,j,k}$ is the per capita residential electricity activity data for municipality *i* within state *j* year *k*

$SEIFA_{i,j,k}$ is the SEIFA rating for municipality *i* within state j in year *k*

$POP\_HOU_{i,j,k}$ is the population divided by the households for municipality *i* within state j in year *k*

$ARE\_POP_{i,j,k}$ is the LOG(area) divided by the LOG(population) for municipality *i* within state *j* in year *k*

$ARE\_HOU_{i,j,k}$ is the LOG(area) divided by the LOG(households) for municipality *i* within state *j* in year *k*

Table 6 shows the results of the regression model defined in Equation 2.

Table 6: Residential Electricity Regression Model Summary

Variable	Coefficient	p-value	R^2
CONSTANT	2.48	<0.001	0.58
SEIFA	-0.17	<0.001	
POP_HOU	-0.25	<0.001	
ARE_POP	3.31	<0.001	
ARE_HOU	-1.67	<0.001	

The next stage is to derive the modelled residential electricity activity data for each municipality. Equation 3 shows the results.

Equation 3: Residential Electricity Activity Data

$$AD\_MOD_{i,j,k} = \left(CON\_PC_{i,j,k} \times POP_{i,j,k}\right)$$

Where:

$AD\_MOD_{i,j,k}$ is the modelled residential electricity activity data where the tier 2 data is not available for municipality *i* within state *j* in year *k*

$CON\_PC_{i,j,k}$ is the estimated per capita residential electricity activity data for municipality *i* within state *j* in year *k*

$POP_{i,j,k}$ is the population for municipality *i* within state *j* in year *k*

It is important that the modelled residential electricity activity data and actual tier 2 residential electricity activity data for each municipality sums to the residential electricity activity data state total based on the Australian Energy Statistics which is published annually by the Department of Industry, Science, Energy and Resources. Therefore, a correction factor is applied for each state and year for municipalities with modelled residential electricity activity data. Equation 4 shows results.

Equation 4: Correction Factor for Residential Electricity Activity Data

$$CF_{j,k} = \frac{\left[\left(C \times AD\_AES_{j,k}\right) - \sum_i AD\_ACT_{i,j,k}\right]}{\sum_i AD\_MOD_{i,j,k}}$$

Where:

$CF_{j,k}$ is the correction factor for state *j* and year *k*

$AD\_AES_{j,k}$ is the residential electricity activity data based on the Australian Energy Statistics for state *j* and year *k*

$AD\_ACT_{i,j,k}$ is the actual tier 2 residential electricity activity data where available for municipality *i* in state *j* and year *k*

$AD\_MOD_{i,j,k}$ is the modelled residential electricity activity data where the tier 2 data is not available for municipality *i* in state *j* in year *k*

C = 277,777 is the conversion factor to convert GJ to KW

The final stage is to integrate the modelled activity data, emissions factors and conversion factors to derive the residential electricity emissions for municipalities without tier 2 activity data. Equation 5 shows the results.

Equation 5: Tier 1 Residential Electricity Emissions

$$Emissions_{i,j,k} = \sum_{l=2,3} \left(AD\_MOD_{i,j,k} \times EF_l \times CF_{j,k} \times C\right)$$

Where:

$Emissions_{i,j,k}$ is the residential electricity emissions for municipality *i* in state *j* in year *k*

$AD\_MOD_{i,j,k}$ is the modelled residential electricity activity data where the tier 2 data is not available for municipality *i* in state *j* in year *k*

EF_l is the emissions factor for scope *l*

$CF_{j,k}$ is the correction factor for state *j* in year *k*

C is 0.001 which is the conversion factor

4.1.7 Limitations and Considerations

Since residential electricity activity data is highly correlated with population and households even the modelled data based on the regression model will be very accurate. Therefore, there are no specific limitations or considerations.

4.2 Electricity Commercial

4.2.1 Approach

Commercial electricity is modelled using a combination of Tier 2 local activity data and state level activity data which is apportioned to municipalities based on relevant scaling factors using jobs data. This blended approach ensures commercial electricity emissions are complete whilst also ensuring Tier 2 activity data is utilised where available.

Tier 2 commercial electricity data is available in NSW and QLD. However, the QLD tier 2 data is not complete (i.e. excludes key emitters) and also doesn't properly distinguish between commercial and industrial sectors. More information is provided in Section 4.2.7.

4.2.2 Included Categories

Commercial electricity includes:

- Scope 2 emissions from electricity consumption for stationary energy sources.
- Scope 3 emissions from the transmission and distribution of electricity stationary energy sources.

4.2.3 Base Data

Table 7: Base Data for Commercial Electricity

Availability	Description	Granularity	Source	Source ID
NSW	NSW electricity municipality activity data by sector	Municipality	Ausgrid	SE-R2
National	State level stationary energy activity data by sector	State	Australian Energy Statistics	SE-R3
National	Jobs in the INDP level 1 category	Municipality	Australian Bureau of Statistics	BMS-R4

4.2.4 Emissions Factors

This section using the grid electricity emissions factors which are provided in Table 45 of the Appendix.

4.2.5 Method SEE_CO_T2_V1 – Local Activity Data

Tier 2 commercial electricity activity data is available from Ausgrid (NSW). Data is available for 32 municipalities in NSW out of a possible 128. Table 5 in Section 4.1.5 shows the municipalities with Tier 2 residential electricity activity data. The same municipalities have tier 2 commercial electricity activity data.

Emissions are derived by integrating the activity data alongside the emissions factors and conversion factors. Equation 6 shows the results.

Equation 6: Tier 2 Commercial Electricity Emissions

$$Emissions_{i,j,k} = \sum_{l=2,3} (AD_{i,j,k} \times EF_l \times C)$$

Where:

$Emissions_{i,j,k}$ is the commercial electricity emissions for municipality *i* within state *j* in year *k*

$AD_{i,j,k}$ is the tier 2 commercial electricity activity data for municipality *i* within state *j* in year *j*

EF_l is the emissions factor for scope *l*

C is 0.001 which is the conversion factor

4.2.6 Method SEE_CO_T1_V1 – Modelled Data

For municipalities without Tier 2 commercial electricity data available a modelled approach is required. Municipalities without commercial electricity data currently include all municipalities except for 32 municipalities in NSW.

State level commercial electricity activity data is available via Table F of the Australian Energy Statistics. This is scaled to the municipality level via jobs allocation. Commercial jobs are based on the Australian Bureau of Statistics jobs in the INDP level 1 category and are limited to the categories in Table 8.

Table 8: Electricity Commercial Subsectors

Subsector	Subsector	Subsector
Wholesale trade	Rental hiring and real estate services	Healthcare and social assistance
Retail trade	Professional, scientific and technical services	Arts and recreation services
Accommodation and food services	Administrative and support services	Other services
Information media and telecommunications	Public administration and safety	
Financial and insurance services	Education and training	

Scaling factors are derived by aggregating these jobs and apportioning state level commercial activity data to the municipality level. Equation 7 shows the results.

Equation 7: Scaling Factors for Commercial Electricity

$$SF_{i,j,k} = \frac{C\_JOBS_{i,j,k}}{\sum_i C\_JOBS_{i,j,k}}$$

Where:

$SF_{i,j,k}$ is the scaling factor for municipality *i* within state *j* in year *k*

$C\_JOBS_{i,j,k}$ is the total commercial jobs for municipality *i* within state *j* in year *k*

The modelled commercial electricity activity data for each municipality can be derived by multiplying the state level commercial electricity data to Equation 7. Equation 8 shows the results.

Equation 8: Commercial Electricity Activity Data

$$AD\_MOD_{i,j,k} = AD\_AES_{j,k} \times SF_{i,j,k}$$

Where:

$AD\_MOD_{i,j,k}$ is the modelled commercial electricity activity data where the tier 2 data is not available for municipality *i* within state *j* in year *k*

$AD\_AES_{j,k}$ is the commercial electricity activity data based on the Australian Energy Statistics for state *j* in year *k*

$SF_{i,j,k}$ is the scaling factor for municipality *i* within state *j* in year *k*

It is important that the modelled commercial electricity activity data and actual tier 2 commercial electricity activity data for each municipality sums to the commercial electricity activity data state total based on the Australian Energy Statistics which is published annually by the Department of Industry, Science, Energy and Resources. Therefore, a correction factor is applied for each state and year for municipalities with modelled commercial electricity activity data. Equation 9 shows results.

Equation 9: Correction Factor for Commercial Electricity Activity Data

$$CF_{j,k} = \frac{\left[\left(C \times AD\_AES_{j,k}\right) - \sum_i AD\_ACT_{i,j,k}\right]}{\sum_i AD\_MOD_{i,j,k}}$$

Where:

$CF_{j,k}$ is the correction factor for state *j* in year *k*

$AD\_AES_{j,k}$ is the commercial electricity activity data based on the Australian Energy Statistics for state *j* in year *k*

$AD\_ACT_{i,j,k}$ is the actual tier 2 commercial electricity activity data where available for municipality *i* within state j in year *j*

$AD\_MOD_{i,j,k}$ is the modelled commercial electricity activity data where the tier 2 data is not available for municipality *i* in state *j* in year *k*

C = 277,777 is the conversion factor to convert GJ to KW

The final stage is to integrate the correction factor alongside the activity data, emissions factors and conversion factors to derive the commercial electricity emissions for municipalities without tier 2 activity data. Equation 10 shows the results.

Equation 10: Tier 1 Commercial Electricity Emissions

$$Emissions_{i,j,k} = \sum_{l=2,3} \left(AD\_MOD_{i,j,k} \times EF_l \times CF_{j,k} \times C \right)$$

Where:

$Emissions_{i,j,k}$ is the commercial electricity emissions for municipality *i* within state *j* in year *k*

$AD\_MOD_{i,j,k}$ is the modelled commercial electricity activity data where the tier 2 data is not available for municipality *i* within state *j* in year *k*

EF_l is the emissions factor for scope *l*

$CF_{j,k}$ is the correction factor for state *j* in year *k*

C is 0.001 which is the conversion factor

4.2.7 Limitations and Considerations

Tier 2 commercial electricity activity data is provided by Ausgrid. It is assumed that Ausgrid's definition of "commercial" is similar to the jobs allocation method using the Australian Bureau of Statistics INDP level 1 category defined in this section. Furthermore, it is assumed that the Ausgrid data is complete and contains all large emitters.

4.3 Electricity Industrial

4.3.1 Approach

There are a range of large emitting facilities across Australia, which in some instances these emitters can be orders of magnitude higher than other sources of emissions within a municipality. Because of the scale of these emissions, they can significantly impact the total emissions for a municipality, and without being properly accounted for can lead to inflation of emission estimates for other municipalities without such facilities.

Therefore, industrial electricity is modelled using a hybrid approach which incorporates key emitters, via the safeguard mechanism, and state level activity data which is apportioned to municipalities based on relevant scaling factors using jobs data. This ensures industrial electricity emissions are complete whilst also ensuring location based key emitters are incorporated.

4.3.2 Included Categories

Industrial electricity includes:

- Scope 2 emissions from electricity consumption for stationary energy sources.
- Scope 3 emissions from the transmission and distribution of electricity stationary energy sources.

4.3.3 Base Data

Table 9: Base Data for Industrial Electricity

Availability	Description	Granularity	Source	Source ID
National	State level stationary energy activity data by sector	State	Australian Energy Statistics	SE-R3
National	Safeguard Mechanism	Operator	Safeguard Mechanism	SE-R4
National	National Pollutants Inventory	Operator	National Pollutants Inventory	SE-R5
National	Jobs in the INDP level 2 category	Municipality	Australian Bureau of Statistics	BMS-R5
National	Jobs in the OCCP level 1 category	Municipality	Australian Bureau of Statistics	BMS-R6

4.3.4 Emissions Factors

This section using the grid electricity emissions factors provided in Table 45 and stationary energy emissions factors provided in Table 48, Table 49 and Table 50 of the Appendix.

4.3.5 Method SEE_IN_T2_V1 - Key Emitters (Stage 1)

To identify the largest emitters in Australia, the primary source for information for the large emitters is the Safeguard Mechanism Registry. Table 10 shows a summary of the Safeguard Mechanism data by state in 2020.

Table 10: Safeguard Mechanism Data by State, 2020

State	No. of Safeguard Mechanism Facilities	Total Emissions for Safeguard Mechanism Facilities (t CO_2e)
NSW	38	25,442,209
VIC	18	6,395,091
SA	10	6,820,754
WA	66	46,222,327
QLD	63	37,507,390
TAS	6	2,062,635
NT	9	9,981,573
ACT	0	0
Others	7	6,709,406

These facilities are not evenly distributed across the different activity sectors within the community. Table 11 shows a summary of the Safeguard Mechanism data by ANZSIC categories of industrial sectors in 2020. This shows the top emitting sector to be Oil and Gas Extraction.

Table 11: Safeguard Mechanism Data by Sector, 2020

Sector	Emissions (t CO_2e)
Oil and Gas Extraction	41,297,758
Coal Mining	33,455,437
Iron Smelting and Steel Manufacturing	8,720,579
Iron Ore Mining	7,200,636
Cement and Lime Manufacturing	5,925,403
Port and Water Transport Terminal Operations	5,543,542
Alumina Production	5,258,984
Fossil Fuel Electricity Generation	5,137,823
Aircraft Manufacturing and Repair Services	3,354,498
Petroleum Refining and Petroleum Fuel Manufacturing	2,248,161
Aluminium Smelting	2,191,231
Explosive Manufacturing	1,708,542
Gold Ore Mining	1,477,315

Fertiliser Manufacturing	1,433,772
Bauxite Mining	1,272,829
Rail Freight Transport	1,205,849
Nickel Ore Mining	921,477
Synthetic Resin and Synthetic Rubber Manufacturing	824,238
Industrial and Agricultural Chemical Product Wholesaling	800,136
Pulp, Paper and Paperboard Manufacturing	603,183
Basic Organic Chemical Manufacturing	561,618
Silver-Lead-Zinc Ore Mining	512,550
Other Food Product Manufacturing n.e.c.	351,980
Gas Supply	347,313
Other Metal Ore Mining	330,044
Glass and Glass Product Manufacturing	315,021
Copper, Silver, Lead and Zinc Smelting and Refining	292,446
Sewerage and Drainage Services	247,533
Mineral Sand Mining	246,459
Other Warehousing and Storage Services	237,434
Copper Ore Mining	229,614
Metal Coating and Finishing	217,171
Basic Inorganic Chemical Manufacturing	173,086
Water Passenger Transport	145,819
Railway Rolling Stock Manufacturing and Repair Services	119,792
Human Pharmaceutical and Medicinal Product Manufacturing	114,936
Other Basic Non-Ferrous Metal Manufacturing	107,847
Other Non-Metallic Mineral Product Manufacturing	58,758

To allocate the Safeguard Facilities to specific municipalities, they need to be mapped onto a geographical distribution. The Safeguard Mechanism data does not store specific geographical information, so this cannot be applied directly. Therefore, the National Pollutants Inventory (NPI) is integrated to derive the municipality for each Safeguard facility. This is a manual process which links specific facilities to the NPI registry. This process needs to be done manually, since the different mechanisms of linkage (such as facility name, organisation name, organisation ABN, ANZSIC codes) do not uniformly line up. Note that not every facility can be linked – there are multiple entries in the Safeguard facility data that do not link to specific locations (such as ATGO gas distribution networks). Table 12 shows the results of this process for the Safeguard mechanism facilities in Victoria.

Table 12: Safeguard Mechanism Facilities Within Victoria

Facility Name	Operator	Emissions (t CO_2e)	Municipality
Portland Aluminium Smelter	ALCOA PORTLAND ALUMINIUM PTY LTD	614,289	Glenelg
Lang Lang	BEACH ENERGY (OPERATIONS) LIMITED	160,631	Cardinia
Otway	BEACH ENERGY (OPERATIONS) LIMITED	137,163	Corangamite
Western Port Works	BLUESCOPE STEEL LIMITED	108,159	Mornington Peninsula
Victoria	CSL AUSTRALIA PTY LTD	114,936	Hume
Gippsland Basin facility	ESSO AUSTRALIA RESOURCES PTY LTD	1,835,088	Mornington Peninsula
Sewerage East	MELBOURNE WATER CORPORATION	121,089	Greater Dandenong
Sewerage West	MELBOURNE WATER CORPORATION	126,444	Wyndham
Mobil Altona Refinery	MOBIL REFINING AUSTRALIA PTY. LTD.	600,131	Hobsons Bay
Dandenong	OCEANIA GLASS PTY LTD	110,628	Greater Dandenong
Opal Australian Paper Maryvale Mill	PAPER AUSTRALIA PTY LTD	328,984	Latrobe
Qenos Altona Manufacturing	QENOS PTY LTD	353,050	Hobsons Bay
Qenos Botany Manufacturing	QENOS PTY LTD	471,188	Hobsons Bay
Nowra Plant	SHOALHAVEN STARCHES PTY LTD	351,980	Hobsons Bay
InfraBuild Steel Laverton Steel Mill	THE AUSTRALIAN STEEL COMPANY (OPERATIONS) PTY LTD	109,012	Wyndham
TT-Line - Victorian Operation	TT-LINE COMPANY PTY. LTD.	145,819	Port Phillip
Geelong Refinery	VIVA ENERGY REFINING PTY LTD	985,025	Greater Geelong

The next stage is to make a determination of the proportion of emissions attributable to electricity consumption and industrial processes. At this stage gas consumption of key emitters is excluded due to complications around the determination method whilst ensuring the gas consumption activity data for each subsectors sums to the state totals.

Before the determination of electricity consumption can be calculated the determination method for industrial processes is required. This method looks at the ratio of Scope 1 stationary energy emissions based on the Australian Energy Statistics and corresponding stationary energy emissions factors (Table 48, Table 49 and Table 50) for each sector against the total scope 1 emissions for each sector based on Australia's National Greenhouse Accounts. Equation 11 shows the results.

Equation 11: Proportion of Industrial Processes Emissions

$$P\_IP_{j,k,m} = \frac{Emissions\_AEGIS_{j,k,m} - \sum Emissions\_AES_{j,k,m}}{Emissions\_AEGIS_{j,k,m}}$$

Where:

$P\_IP_{j,k,m}$ is the proportion of industrial processes emissions for state *j* in year *k* by sector *m*

$Emissions\_AES_{j,k,m}$ is the Australian Energy Statistics scope 1 stationary energy emissions for state *j* in year *k* by sector *m*

$Emissions\_AEGIS_{j,k,m}$ is Australia's National Greenhouse Accounts total scope 1 emissions for state *j* in year *k* by sector *m*

Once the proportion of industrial processes emissions for each safeguard facility have been accounted for a proportion of the remaining emissions are then allocated to electricity emissions. Equation 12 shows the remaining emissions.

Equation 12: Remaining Emissions after Industrial Processes Allocation

$$Emissions\_Remaining_{i,j,k,m,n} = \left(1 - P\_IP_{j,k,m}\right) \times Emissions\_KEY_{j,k,m,n}$$

Where:

$Emissions\_Remaining_{i,j,k,m,n}$ is the remaining emissions for municipality *i* within state *j* in year *k* by facility *n* within sector *m* after industrial processes allocation

$P\_IP_{j,k,m}$ is the proportion of industrial processes emissions for state *j* in year *k* by sector *m*

$Emissions\_KEY_{i,j,k,m,n}$ is the total safeguard emissions for municipality *i* within state *j* in year *k* by facility *n* within sector *m*

The next stage is to determine the proportion of electricity emissions based off the remaining emissions in Equation 12. This method uses Australia's National Greenhouse

Account Emissions and calculates the ratio of scope 2 emissions relative to scope 1 emissions for each state and sector. Equation 13 shows the results.

Equation 13: Electricity Emissions for Key Emitters

$$P\_EL_{j,k,m} = \frac{Emissions\_AEGIS_{j,k,2,m}}{Emissions\_AEGIS_{j,k,1,m}}$$

Where:

$P\_EL_{j,k,m}$ is the proportion of electricity emissions for state *j* in year *k* by sector m

$Emissions\_AEGIS_{j,k,l,m}$ is Australia's National Greenhouse Accounts emissions for state *j* in year *k* by scope *l* and sector m

The final stage is to multiply the proportion of electricity emissions by the remaining emissions of each safeguard facility after the industrial processes allocation method. Equation 14 shows the results.

Equation 14: Tier 2 Industrial Electricity Emissions

$$Emissions_{i,j,k,m,n} = P\_EL_{j,k,m} \times Emissions\_Remaining_{i,j,k,m,n}$$

Where:

$Emissions_{l,j,m,n}$ is the electricity emissions for municipality *i* within state *j* in year *k* by facility *n* within sector *m*

$P\_EL_{j,k,m}$ is the proportion of electricity emissions for state *j* in year *k* by sector *m*

$Emissions\_Remaining_{i,j,k,m,n}$ is the remaining emissions for municipality *i* within state *j* in year *k* by facility *n* within sector *m* after industrial processes allocation

4.3.6 Method SEE_IN_T1_V1 - Modelled Data (Stage 2)

State level industrial electricity consumption activity data is available via Table F of the Australian Energy Statistics by subsector. This is scaled to the municipality level via Australian Bureau of Statistics INDP level 2 category jobs allocation. This is integrated with the key emitters emissions data to ensure electricity industrial emissions are complete whilst also incorporating location based key emitters.

Due to the different subsectors between Australian Energy Statistics and Australian Bureau of Statistics a manual lookup table is derived to compare 'apples with apples'. These lookup tables are provided in Table 56 and Table 57 in the Appendix. Table 13 shows the industrial subsectors used in this section.

Table 13: Industrial Electricity Subsectors

Subsector	Category
Mining	Non-metallic mineral products
Manufacturing	Machinery and equipment
Textile, clothing, footwear and leather	Electricity gas and water
Wood and wood products	Construction
Pulp, paper and printing	Transport services and storage

Scaling factors are derived by apportioning state level industrial activity data to the municipality level for each sector in Table 13. Equation 15 shows the results.

Equation 15: Scaling Factors for Industrial Electricity Consumption

$$SF_{i,j,k,m} = \frac{I\_JOBS_{i,j,k,m}}{\sum_i I\_JOBS_{i,j,k,m}}$$

Where:

$SF_{i,j,k,m}$ is the scaling factor for municipality *i* within state *j* in year *k* for sector *m*

$I\_JOBS_{i,j,k,m}$ is the industrial jobs for municipality *i* within state *j* in year *k* for sector *m*

The modelled industrial electricity activity data for each municipality can be derived by multiplying the state level industrial electricity data to Equation 15. Equation 16 shows the results.

Equation 16: Modelled Industrial Electricity Activity Data

$$AD\_MOD_{i,j,k,m} = AD\_AES_{j,k,m} \times SF_{i,j,k,m}$$

Where:

$AD\_MOD_{i,j,k,m}$ is the modelled industrial electricity activity data where the tier 2 data is not available for municipality *i* within state *j* in year *k* for sector *m*

$AD\_AES_{j,k,m}$ is the commercial electricity activity data based on the Australian Energy Statistics for state *j* and year *k* for sector *m*

$SF_{i,j,k,m}$ is the scaling factor for municipality *i* within state *j* in year *k* for sector *m*

The final stage is to integrate the activity data, emissions factors and conversion factors to derive the modelled tier 1 industrial electricity emissions for all municipalities. Equation 17 shows the results.

Equation 17: Modelled Industrial Electricity Emissions

$$Emissions\_MOD_{i,j,k,m} = \sum_{l=2,3} \left(AD\_MOD_{i,j,k,m} \times EF_l \times C\right)$$

Where:

$Emissions\_MOD_{i,j,k,m}$ is the modelled industrial electricity emissions for municipality *i* within state *j* in year *k* for sector *m*

$AD\_MOD_{i,j,k,m}$ is the modelled industrial electricity activity data for municipality *i* within state *j* year *k* for sector *m*

EF_l is the emissions factor for scope *l*

C is 0.001 which is the conversion factor

4.3.7 Method SEE_IN_T12_V1 - Hybrid Approach (Stage 3)

The next stage is to integrate the key emitter data in Section 4.3.5 and modelled emissions in Section 4.3.6 to derive the industrial electricity emissions for each municipality. It is important that key emitters industrial emissions and modelled industrial emissions for each municipality and sector sums to the industrial electricity emissions data by sector state totals based on the Australian Energy Statistics which is published annually by the Department of Industry, Science, Energy and Resources. Therefore, the key emitters data is removed from the Australian Energy Statistics state totals for each sector and the remaining emissions are apportioned to each municipality based on jobs allocation. A correction factor is applied for each state, sector and year. Equation 18 shows results.

Equation 18: Correction Factor for Industrial Electricity Emissions

$$CF_{j,k,m} = \frac{\left[\left(C \times Emissions\_AES_{j,k,m}\right) - \sum_i Emissions\_KEY_{i,j,k,m}\right]}{\sum_i Emissions\_MOD_{i,j,k,m}}$$

Where:

$CF_{j,k,m}$ is the correction factor for state *j* and year *k* for sector *m*

$Emissions\_AES_{j,k,m}$ is the industrial electricity emissions based on the Australian Energy Statistics for state *j* and year *k* for sector *m*

$Emissions\_KEY_{i,j,k,m}$ is the key emitters industrial electricity emissions for municipality *i* within state *j* and year *k* for sector *m*

$Emissions\_MOD_{i,j,k,m}$ is the modelled industrial electricity emissions where the industrial emissions is less than the sum of the key emitters for municipality *i* within state *j* and year *k* for sector *m*

C = 277,777 is the conversion factor to convert GJ to KW

The final stage is to integrate the correction factor alongside the modelled industrial electricity emissions for municipalities that have no key emitters data or where the key emitters data is less than the modelled state level data for each sector. Please note for municipalities where the key emitters data is higher than the modelled state level data for each sector the key emitters data is used. Equation 19 shows the results.

Equation 19: Industrial Electricity Emissions

$$Emissions_{i,j,k,m} = \begin{cases} Emissions\_KEY_{i,j,k,m} & if\ Emissions\_KEY_{i,j,k,m} > Emissions_{i,j,k,m} \\ Emissions_{i,j,k,m} \times CF_{l,j,m} & if\ Emissions\_KEY_{i,j,k,m} < Emissions_{i,j,k,m} \end{cases}$$

Where:

$Emissions_{i,j,k,m}$ is the industrial electricity emissions for municipality *i* within state *j* in year *k* for sector *m*

$Emissions\_KEY_{i,j,k,m}$ is the total industrial electricity key emitters emissions municipality *i* within state j and year *k* for sector *m*

$CF_{j,k,m}$ is the correction factor for state *j* within year *k* for sector *m*

4.3.8 Limitations and Considerations

A proportion of the key emitters emissions data via the Safeguard Mechanism is allocated to each of the electricity and industrial processes sectors. This allocation method uses data from Australian Energy Statistics and Australia's National Greenhouse Accounts to effectively derive an electricity ratio component at the state and sector level. However, the proportion of electricity and industrial process for each facility is likely to vary considerably even within each sector and state.

5. Stationary Energy - Gas

Stationary energy, specifically gas, relates to gas consumed at stationary locations, which largely means buildings. It includes gas consumed by the residential, commercial and industrial sectors.

5.1 Gas Residential

5.1.1 Approach

Residential gas is modelled using a combination of Tier 2 local activity data and state level activity data which is apportioned to municipalities based on relevant scaling factors based on residential characteristics such as population, households, and gas connections. This ensures residential gas emissions are complete whilst also enabling Tier 2 activity data to be utilised where available.

Tier 2 activity data is available for certain NSW municipalities. All other municipalities use modelled state level data.

5.1.2 Included Categories

Residential gas includes:

- Scope 1 emissions from stationary energy sources (excluding energy production supplied to the grid)
- Scope 3 emissions from the transmission and distribution of gas stationary energy sources

5.1.3 Base Data

Table 14: Base Data for Residential Gas

Availability	Description	Granularity	Source	Source ID
National	State level stationary energy activity data by sector	State	Australian Energy Statistics	SE-R3
NSW	NSW residential gas municipality activity data	Municipality	Jemena	SE-R6
NSW, VIC, QLD, SA and NT	Natural Gas Availability	Postcode	Australian Gas Networks	SE-R7
TAS	Tas Gas Pipeline Locator	Postcode	Tas Gas Networks	SE-R8
WA	WA Gas Pipeline Network Coverage Maps	Postcode	ATCO	SE-R9
National	Population	Municipality	Australian Bureau of Statistics	BMS-R1

National	DWTD Dwelling type - Total	Municipality	Australian Bureau of Statistics	BMS-R2
National	SEIFA	Municipality	Australian Bureau of Statistics	BMS-R3
National	Local Government Area Concordances	Municipality	Australian Bureau of Statistics	BMS-R9
National	Postcode Concordances	Postcode	Australian Bureau of Statistics	BMS-R10

5.1.4 Emissions Factors

This section using emissions factors for the consumption of gaseous fuels (scope 1) and natural gas leakage emissions factors (scope 3) which are provided in Table 46 and Table 47 of the Appendix respectively.

Scope 3 emissions factors are derived by multiplying the unaccounted for gas emissions factor by the gas leakage emissions factors for each gas type and applying a conversion factor. Equation 20 shows the results.

Equation 20: Scope 3 Gas Emissions Factor

$$EF_{j,g} = EF\_GL_{j,g} \times EF\_UAG_j \times C$$

Where:

$EF_{j,g}$ is the scope 3 gas emissions factor for state j and gas type g

$EF\_GL_{j,g}$ is the gas leakage emissions factor for state j and gas type g

EF_UAG_j is the unaccounted for gas emissions factor for state j

C is 0.0055 is the conversion factor

5.1.5 Method SEG_RE_T2_V1 – Local Activity Data

Tier 2 residential gas activity data is available from Jemena and is available for 64 municipalities in NSW out of a possible 128. Table 15 shows which NSW municipalities have Tier 2 residential gas activity data.

Table 15: NSW Municipalities with Tier 2 Residential Gas Activity Data

Municipality	Municipality	Municipality	Municipality
Bathurst Regional, NSW	Cumberland, NSW	Lane Cove, NSW	Penrith, NSW
Bayside, NSW	Dubbo Regional, NSW	Leeton, NSW	Randwick, NSW
Blacktown, NSW	Fairfield, NSW	Lithgow, NSW	Ryde, NSW
Bland, NSW	Forbes, NSW	Liverpool, NSW	Shellharbour, NSW
Blayney, NSW	Georges River, NSW	Maitland, NSW	Singleton, NSW
Blue Mountains, NSW	Goulburn Mulwaree, NSW	Mosman, NSW	Strathfield, NSW
Burwood, NSW	Griffith, NSW	Narrandera	Sutherland Shire, NSW
Camden, NSW	Hawkesbury, NSW	Narromine, NSW	Sydney, NSW
Campbelltown, NSW	Hilltops, NSW	Newcastle, NSW	The Hills Shire, NSW
Canada Bay, NSW	Hornsby, NSW	North Sydney, NSW	Waverly, NSW
Canterbury-Bankstown, NSW	Hunters Hill, NSW	Northern Beaches, NSW	Willoughby, NSW
Central Coast, NSW	Inner West, NSW	Oberon, NSW	Wingecarribee, NSW
Cessnock, NSW	Junee, NSW	Orange, NSW	Wollondilly, NSW
Coolamon, NSW	Kiama, NSW	Parkes, NSW	Wollongong, NSW
Cootmundra-Gundagai Regional, NSW	Ku-ring-gai, NSW	Parramatta, NSW	Woollahra, NSW
Cowra, NSW	Lake Macquarie, NSW	Port Stephens, NSW	Yass Valley, NSW

Emissions are derived by integrating the activity data alongside the emissions factors and conversion factors. Equation 21 shows the results.

Equation 21: Tier 2 Residential Gas Emissions

$$Emissions_{i,j,k} = \sum_{l=1,3} (AD_{i,j,k} \times EF_l \times C)$$

Where:

$Emissions_{i,jk}$ is the residential gas emissions for municipality *i* within state j in year *k*

$AD_{i,j,k}$ is the tier 2 residential gas activity data for municipality *i* within state j in year *k*

EF_k is the emissions factor for scope *l*

C is 0.001 which is the conversion factor

5.1.6 Method SEG_RE_T1_V1 – Modelled Data

For municipalities without Tier 2 residential gas activity data available a modelled approach is required. Municipalities without Tier 2 residential gas consumption activity data currently include all municipalities except for 64 municipalities in NSW.

A regression model is used to estimate residential gas activity data for municipalities without Tier 2 activity data based the municipalities with Tier 2 activity data across all reporting periods. Since residential gas consumption is largely driven by population the dependant variable is gas per capita and the independent variables incorporate various combinations of socio-economic index (SEIFA), population, households and land size. Log transformations are applied to ensure normality. The gas availability index for each municipality is not required since this is 1 (100%) for all municipalities with tier 2 residential gas activity data. Equation 22 shows the model formulation.

Equation 22: Regression Model for Residential Gas Activity Data

$$CON\_PC_{i,j,k} = \beta_0 + \beta_1 LOG\left(1/\frac{SEIFA_{i,j,k}}{100}\right) + \beta_2 POP\_HOU_{i,j,k} + \beta_3 ARE\_POP_{i,j,k} + \beta_4 ARE\_HOU_{i,j,k}$$

Where

$CON\_PC_{i,j,k}$ is the per capita residential gas consumption for municipality *i* within state *j* in year *k*

$SEIFA_{i,j,k}$ is the SEIFA rating for municipality *i* within state *j* in year *k*

$POP\_HOU_{i,j,k}$ is the population divided by the households for municipality *i* within state *j* in year *k*

$ARE\_POP_{i,j,k}$ is the LOG(area) divided by the LOG(population) for municipality *i* within state *j* in year *k*

$ARE\_HOU_{i,j,k}$ is the LOG(area) divided by the LOG(households) for municipality *i* within state *j* in year *k*

Table 16 shows the results of the regression model defined in Equation 22.

Table 16: Residential Gas Regression Model Summary

Variable	Coefficient	p-value	R^2
CONSTANT	13.75	<0.001	0.09
POP_HOU	-2.64	<0.001	
ARE_POP	-47.75	<0.001	
ARE_HOU	40.91	<0.001	

The R^2 value of 0.09 suggests there is a great deal of uncertainty around modelling residential gas activity data.

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 and for other states this is estimated based on various data sources. Therefore, gas availability at the municipality level can be estimated using geospatial overlays for eastern states. Equation 23 shows the results.

Equation 23: Gas Availability

$$GA_{i,j} = \frac{\sum P_{p,i,j} \times GA_{p,j}}{\sum P_{p,i,j}}$$

Where

$GA_{i,j}$ is the gas availability for municipality *i* within state *j*

$GA_{p,j}$ is the gas availability for postcode *p* within state *j*

$P_{p,i,j}$ is the proportion of postcode *p* in municipality *i* within state *j*

The modelled residential gas activity data for each municipality can be derived by multiplying the population to Equation 22 and integrating the gas availability index. Equation 24 shows the results.

Equation 24: Residential Gas Activity Data

$$AD\_MOD_{i,j,k} = \left(CON\_PC_{i,j,k} \times POP_{i,j,k}\right) \times GA_{i,j}$$

Where:

$AD\_MOD_{i,j,k}$ is the modelled residential gas activity data where the tier 2 data is not available for municipality *i* in state *j* and year *k*

$CON\_PC_{i,j,k}$ is the estimated per capita residential gas consumption for municipality *i* within state *j* in year *k*

$POP_{i,j,k}$ is the population for municipality *i* within state *j* in year *k*

$GA_{i,j}$ is the gas availability index for municipality *i* within state j

It is important that the modelled residential gas activity data and actual tier 2 residential gas activity data for each municipality sums to the residential gas activity data state total based on the Australian Energy Statistics which is published annually by the Department of Industry, Science, Energy and Resources. Therefore, a correction factor is applied for each state and year for municipalities with modelled residential gas activity data. Equation 25 shows results.

Equation 25: Correction Factor for Tier 1 Residential Gas Activity Data

$$CF_{j,k} = \frac{\left[\left(C \times AD\_AES_{j,k}\right) - \sum_i AD\_ACT_{i,j,k}\right]}{\sum_i AD\_MOD_{i,j,k}}$$

Where:

$CF_{j,k}$ is the correction factor for state *j* in year *k*

$AD\_AES_{j,k}$ is the residential gas activity data based on the Australian Energy Statistics for state *j* in year *k*

$AD\_ACT_{i,j,k}$ is the actual tier 2 residential gas activity data where available for municipality *i* within state *j* and year *k*

$AD\_MOD_{i,j,k}$ is the modelled residential gas activity data where the tier 2 data is not available for municipality *i* in state *j* and year *k*

C = 1,000,000 is the conversion factor

The final stage is to integrate the correction factor alongside the activity data, emissions factors and conversion factors to derive the residential gas emissions for municipalities without tier 2 activity data. Equation 26 shows the results.

Equation 26: Tier 1 Residential Gas Emissions

$$Emissions_{i,j,k} = \sum_{l=1,3} \left(AD\_MOD_{i,j,k} \times EF_l \times CF_{j,k} \times C\right)$$

Where:

$Emissions_{i,j,k}$ is the residential gas emissions for municipality *i* within state *j* in year *k*

$AD\_MOD_{i,j,k}$ is the modelled residential gas activity data where the tier 2 data is not available for municipality *i* within state *j* and year *k*

EF_l is the emissions factor for scope *l*

$CF_{j,k}$ is the correction factor for state *j* in year *k*

C is 0.001 which is the conversion factor

5.1.7 Limitations and Considerations

Due to the difficulties modelling residential gas consumption there is a great deal of uncertainty around modelled residential gas emissions. The key limitations are around uneven gas availability within each municipality and that gas consumption is not strongly correlated with various population and household factors.

5.2 Gas Commercial

5.2.1 Approach

Commercial gas is modelled based on state level activity data which is apportioned to municipalities based on relevant scaling factors using jobs data. Tier 2 commercial gas data is available in NSW. However, the NSW Tier 2 data is not complete (i.e., excludes key emitters) and it also doesn't properly distinguish between commercial and industrial sectors.

5.2.2 Included Categories

Commercial gas includes:

- Scope 1 emissions from stationary energy sources (excluding energy production supplied to the grid).
- Scope 3 emissions from the transmission and distribution of gas stationary energy sources.

5.2.3 Base Data

Table 17: Base Data for Commercial Gas

Availability	Description	Granularity	Source	Source ID
National	State level commercial gas consumption data	State	Australian Energy Statistics	SE-R3
NSW	NSW residential gas municipality activity data	Municipality	Jemena	SE-R6
NSW, VIC, QLD, SA and NT	Natural Gas Availability	Postcode	Australian Gas Networks	SE-R7
TAS	Tas Gas Pipeline Locator	Postcode	Tas Gas Networks	SE-R8
WA	WA Gas Pipeline Network Coverage Maps	Postcode	ATCO	SE-R9
National	Jobs in the INDP level 1 category	Municipality	Australian Bureau of Statistics	BMS-R4
National	Local Government Area Concordances	Municipality	Australian Bureau of Statistics	BMS-R9
National	Postcode Concordances	Postcode	Australian Bureau of Statistics	BMS-R10

5.2.4 Emissions Factors

This section using emissions factors for the consumption of gaseous fuels (scope 1) and natural gas leakage emissions factors (scope 3) which are provided in Table 46 and Table 47 of the Appendix respectively.

Similarly, to Section 5.1.4, Scope 3 emissions factors are derived by multiplying the unaccounted for gas emissions factor by the gas leakage emissions factors for each gas type and applying a conversion factor. See Equation 20 for more details.

5.2.5 Method SEG_CO_T1_V1 – Modelled Data

State level commercial gas consumption activity data is available via Table F of the Australian Energy Statistics. This is scaled to the municipality level via jobs allocation. Commercial jobs are based on the Australian Bureau of Statistics jobs in the INDP level 1 category and are limited to the categories in Table 8.

Table 18: Gas Commercial Subsectors

Subsector	Subsector	Subsector
Wholesale trade	Rental hiring and real estate services	Healthcare and social assistance
Retail trade	Professional, scientific and technical services	Arts and recreation services
Accommodation and food services	Administrative and support services	Other services
Information media and telecommunications	Public administration and safety	
Financial and insurance services	Education and training	

Scaling factors are derived by aggregating these jobs and apportioning state level commercial activity data to the municipality level. Equation 27 shows the results.

Equation 27: Scaling factors for commercial gas

$$SF_{i,j,k} = \frac{C\_JOBS_{i,j,k}}{\sum_i C\_JOBS_{i,j,k}}$$

Where:

$SF_{i,j,k}$ is the scaling factor for municipality *i* within state *j* in year *k*

$C\_JOBS_{i,j,k}$ is the total commercial jobs for municipality *i* within state *j* in year *k*

The next stage is to incorporate the gas availability index and scaling factors defined in Equation 27 to derive the residential gas activity data for each municipality. Equation 28 shows the results.

Equation 28: Commercial Gas Activity Data

$$AD\_MOD_{i,j,k} = SF_{i,j,k} \times AD\_AES_{i,j} \times GA_{i,j}$$

Where:

$AD\_MOD_{i,j,k}$ is the modelled activity data for municipality *i* within state *j* in year *k*

$SF_{i,j,k}$ is the scaling factor for municipality *i* within state *j* in year *k*

$AD\_AES_{j,k}$ is the commercial gas activity data based on the Australian Energy Statistics for state *j* and year *k*

$GA_{i,j}$ is the gas availability index for municipality *i* within state *j*

It is important that the modelled commercial gas activity data for each municipality sums to the commercial gas activity data state total based on the Australian Energy Statistics which is published annually by the Department of Industry, Science, Energy and Resources. Therefore, a correction factor is applied for each state and year. Equation 29 shows results.

Equation 29: Correction Factor for Commercial Gas Activity Data

$$CF_{j,k} = \frac{C \times AD\_AES_{j,k}}{\sum_i AD\_MOD_{i,j,k}}$$

Where:

$CF_{j,k}$ is the correction factor for state *j* in year *k*

$AD\_AES_{j,k}$ is the commercial gas activity data based on the Australian Energy Statistics for state *j* in year *k*

$AD\_MOD_{i,j,k}$ is the modelled commercial gas activity data where the tier 2 data is not available for municipality *i* within state *j* and year *k*

C = 1,000,000 is the conversion factor

The final stage is to integrate the modelled activity data alongside the emissions factors and conversion factors to derive the commercial gas emissions for each municipality. Equation 30 shows the results.

Equation 30: Commercial Gas Emissions

$$Emissions_{i,j,k} = \sum_{l=1,3} \left(AD\_MOD_{i,j,k} \times EF_l \times CF_{j,k} \times C \right)$$

Where:

$Emissions_{i,j,k}$ is the commercial gas emissions for municipality *i* within state j in year *k*

$AD\_MOD_{i,j,k}$ is the modelled commercial gas activity data for municipality *i* in state j and year *k*

EF_l is the emissions factor for scope *l*

$CF_{j,k}$ is the correction factor for state j in year *k*

C is 0.001 which is the conversion factor

5.2.6 Limitations and Considerations

Tier 2 commercial gas data is available in NSW. However, the NSW tier 2 data is not complete (i.e. excludes key emitters) and also doesn't properly distinguish between commercial and industrial sectors. As better and more specifically complete data becomes available this will be incorporated where possible.

5.3 Gas Industrial

5.3.1 Approach

There are a range of large emitting facilities across Australia, and in some instances these emitters can be orders of magnitude higher than other sources of emissions within a municipality. Because of the scale of these emissions, they can significantly impact the total emissions for a municipality, and without being properly accounted for can lead to inflation of emission estimates for other municipalities without such facilities.

However, emissions for these facilities are typically only provided as a total and not split by an electricity and gas component. Due to the complications around gas relative to electricity (i.e. gas availability) industrial gas is modelled based on state level activity data which is apportioned to municipalities based on relevant scaling factors using jobs data. As soon as the gas component of the key emitters can be modelled more accurately this will be incorporated into the methodology.

5.3.2 Included Categories

Industrial gas includes:

- Scope 1 emissions from stationary energy sources (excluding energy production supplied to the grid)
- Scope 3 emissions from the transmission and distribution of gas stationary energy sources

5.3.3 Base Data

Table 19: Base Data for Industrial Gas

Availability	Description	Granularity	Source	Source ID
National	State level industrial gas consumption data	State	Australian Energy Statistics	SE-R3
NSW	NSW residential gas municipality activity data	Municipality	Jemena	SE-R6
NSW, VIC, QLD, SA and NT	Natural Gas Availability	Postcode	Australian Gas Networks	SE-R7
TAS	Tas Gas Pipeline Locator	Postcode	Tas Gas Networks	SE-R8
WA	WA Gas Pipeline Network Coverage Maps	Postcode	ATCO	SE-R9
National	Jobs in the INDP level 1 category	Municipality	Australian Bureau of Statistics	BMS-R4
National	Local Government Area Concordances	Municipality	Australian Bureau of Statistics	BMS-R9

National	Postcode Concordances	Postcode	Australian Bureau of Statistics	BMS-R10

5.3.4 Emissions Factors

This section uses emissions factors for the consumption of gaseous fuels (scope 1) and natural gas leakage emissions factors (scope 3) which are provided in Table 46 and Table 47 of the Appendix respectively.

Similarly to Section 5.1.4, Scope 3 emissions factors are derived by multiplying the unaccounted for gas emissions factor by the gas leakage emissions factors for each gas type and applying a conversion factor. See Equation 20 for more details.

5.3.5 Method SEG_IN_T1_V1 – Modelled Data

State level industrial gas consumption activity data is available via Table F of the Australian Energy Statistics. This is scaled to the municipality level via jobs allocation. Due to the different subsectors between Australian Energy Statistics and Australian Bureau of Statistics a manual lookup table is derived to compare 'apples with apples'. These lookup tables are provided in Table 56 and Table 57 in the Appendix. Table 20 shows the industrial subsectors used in this section.

Table 20: Industrial Gas Subsectors

Subsector	Category
Mining	Non-metallic mineral products
Manufacturing	Machinery and equipment
Textile, clothing, footwear and leather	Electricity gas and water
Wood and wood products	Construction
Pulp, paper and printing	Transport services and storage

Scaling factors are derived by apportioning state level industrial gas activity data to the municipality level for each sector in Table 20. Equation 31 shows the results.

Equation 31: Scaling Factors for Industrial Gas Consumption

$$SF_{i,j,k,m} = \frac{I\_JOBS_{i,j,k,m}}{\sum_i I\_JOBS_{i,j,k,m}}$$

Where:

$SF_{i,j,k,m}$ is the scaling factor for municipality *i* within state *j* in year *k* for sector *m*

$I\_JOBS_{i,j,k,m}$ is the industrial jobs for municipality *i* within state *j* in year *k* for sector *m*

The next stage is to incorporate the gas availability index and scaling factors to derive the industrial gas activity data for each municipality. Equation 32 shows the results.

Equation 32: Industrial Gas Activity Data

$$AD\_MOD_{i,j,k.m} = SF_{i,j,k,m} \times AD\_AES_{j,k,m} \times GA_{i,j}$$

Where:

$AD\_MOD_{i,j,k,m}$ is the modelled activity data for municipality *i* within state *j* in year *k* for sector *m*

$SF_{i,j,k,m}$ is the scaling factor for municipality *i* within state *j* in year *k* for sector *m*

$AD\_AES_{j,k,m}$ is the industrial gas activity data based on the Australian Energy Statistics for state *j* and year *k* for sector *m*

$GA_{i,j}$ is the gas availability index for municipality *i* within state *j*

The final stage is to integrate the activity data, emissions factors and conversion factors to derive the industrial gas emissions for all municipalities. Equation 33 shows the results.

Equation 33: Industrial Gas Emissions

$$Emissions_{i,j,k,m} = \sum_{l=1,3} (AD\_MOD_{i,j,k,m} \times EF_l \times C)$$

Where:

$Emissions_{i,j,k,m}$ is the industrial gas emissions for municipality *i* in state *j* in year *k* for sector *m*

$AD\_MOD_{i,j,k,m}$ is the modelled industrial gas activity data for municipality *i* in state *j* in year *k* for sector *m*

EF_l is the emissions factor for scope *l*

C is 0.001 which is the conversion factor

5.3.6 Limitations and Considerations

Key emitters data has been excluded due to complications around apportioning the gas component for each key emitter within each sector.

6. Industrial Processes and Product Use (IPPU)

The industrial processes and product use (IPPU) sector covers the greenhouse gas emissions resulting from various industrial activities that produce emissions which are not directly the result of energy consumed during the process, and the use of man-made greenhouse gases in products – namely refrigerants.

6.1 Product Use – Refrigerants

6.1.1 Approach

This method takes data from Australia's National Greenhouse Accounts and is integrated alongside relevant scaling factors to derive product use emissions for refrigeration and air conditioning.

6.1.2 Included Categories

Scope 1 emissions from refrigerant product use within the boundary. Refrigerants include residential refrigeration, commercial refrigeration, industrial refrigeration, residential air conditioning, commercial air conditioning and transport air conditioning.

6.1.3 Base Data

Table 21: Refrigerants Base Data

Availability	Description	Granularity	Source	Source ID
National	DWTD Dwelling type - Total	Municipality	ABS	BMS-R2
National	Jobs in the INDP level 1 category	Municipality	ABS	BMS-R4
National	Jobs in the INDP level 2 category	Municipality	ABS	BMS-R5
National	Register of motor vehicles by LGA and vehicle type	Municipality	ABS	TRA-R1
National	Refrigeration and air-condition emissions	State	Australia's National Greenhouse Accounts	NGA-R1

6.1.4 Emissions Factors

There are no emissions factors since these are embedded in Australia's National Greenhouse Accounts product use emissions.

6.1.5 Method IPPU_PU_T1_V1 - Modelled Data

State level refrigerants emissions data, which is published by Australia's National Greenhouse Accounts (AEGIS), is available by eight subsectors. These 8 subsectors are condensed into 6 subsectors by aggregating similar subsectors after applying suitable scaling factors to the municipality level. Table 22 shows the AEGIS categories for refrigerants and the corresponding snapshot emissions categories and scaling factors.

Table 22: AGEIS Refrigerants concordances

AGEIS Category	AEGIS ID	Snapshot refrigerant category	Snapshot ID	Scaling Factor	Scaling Factor ID
Stand-alone Commercial Applications	SCA	Commercial refrigeration	CR	Commercial jobs	C_JOBS
Industrial refrigeration including food processing and cold storage	IR	Industrial refrigeration	IR	Transport jobs	T_JOBS
Medium and large commercial refrigeration	MLCF	Industrial refrigeration	IR	Food processing jobs	F_JOBS
Domestic refrigeration	DR	Residential refrigeration	RR	Households	HOU
Mobile air-conditioning	MAC	Transport air conditioning	TAR	Passenger Vehicles	VEH
Domestic stationary air conditioning	DSAR	Residential air conditioning	RAC	Households	HOU
Commercial air conditioning	CAC	Commercial air conditioning	CAC	Commercial Jobs	C_JOB
Transport refrigeration	TR	Industrial refrigeration	IR	Heavy Vehicles	H_VEH

For each subsector of emissions, a specific scaling factor has been established, to scale the state emissions to the municipality level. Equation 34 shows the results.

Equation 34: Scaling Factors for refrigeration

$$SF_{i,j,k,C\_JOBS} = \frac{C\_JOBS_{i,j,k}}{\sum_i C\_JOBS_{i,j,k}}$$

$$SF_{i,j,k,T\_JOBS} = \frac{T\_JOBS_{i,j,k}}{\sum_i T\_JOBS_{i,j,k}}$$

$$SF_{i,j,k,F\_JOBS} = \frac{F\_JOBS_{i,j,k}}{\sum_i F\_JOBS_{i,j,k}}$$

$$SF_{i,j,k,HOU} = \frac{HOU_{i,j,k}}{\sum_i HOU_{i,j,k}}$$

$$SF_{i,j,k,VEH} = \frac{VEH_{i,j,k}}{\sum_i VEH_{i,j,k}}$$

$$SF_{i,j,k,H\_VEH} = \frac{H\_VEH_{i,j,k}}{\sum_i H\_VEH_{i,j,k}}$$

Where:

$C\_JOBS_{i,j,k}$ is the number of commercial jobs (defined as the sum of all commercial jobs) of municipality *i* within state *j* in year *k*

$T\_JOBS_{i,j,k}$ is the number of transport jobs (defined as INDP level 1 category 'Transportation, Postal, Warehousing') of municipality *i* within state *j* in year *k*

$F\_JOBS_{i,j,k}$ is the number of food processing jobs (defined as INDP level 2 categories 'Food Product Manufacturing' and 'Beverage and Tobacco Product Manufacturing') of municipality *i* within state *j* in year *k*

$HOU_{i,j,k}$ is the number of households (defined as sum of 'DWTD Dwelling Type – Total') of municipality *i* within state *j* in year *k*

$VEH_{i,j,k}$ is the number of passenger vehicles (defined as sum of 'passenger vehicles', 'campervans' and 'light commercial vehicles') of municipality *i* within state *j* in year *k*

$H\_VEH_{i,j,k}$ is the number of heavy vehicles (defined as sum of 'Light rigid trucks', 'Heavy rigid trucks' and 'articulated trucks) of municipality *i* within state *j* in year *k*

The final step is to integrate the refrigerant emissions by state and sector. Equation 35 shows the results.

Equation 35: Refrigerant emissions by subsector

$$Emissions_{i,j,k,CR} = SF_{i,j,k,C\_JOBS} \times Emissions\_AEGIS_{j,k,SCA}$$

$$Emissions_{i,j,k,IR} = \left(SF_{i,j,k,T\_JOBS} \times Emissions\_AEGIS_{j,k,IR}\right) +$$

$$\left(SF_{i,j,k,F\_JOBS} \times Emissions\_AEGIS_{j,k,MLCF}\right) +$$

$$\left(SF_{i,j,k,H\_VEH} \times Emissions\_AEGIS_{j,k,TR}\right)$$

$$Emissions_{i,j,k,RR} = \left(SF_{i,j,k,HOU} \times Emissions\_AEGIS_{j,k,DR}\right)$$

$$Emissions_{i,j,k,TAR} = \left(SF_{i,j,k,VEH} \times Emissions\_AEGIS_{j,k,MAC}\right)$$

$$Emissions_{i,j,k,RAC} = \left(SF_{i,j,k,HOU} \times Emissions_{AEGIS\,j,k,DSAR}\right)$$

$$Emissions_{i,j,k,CAC} = \left(SF_{i,j,k,C\_JOB} \times Emissions\_AEGIS_{j,k,CAC}\right)$$

Where:

$Emissions_{i,j,k,m}$ is the refrigerant emissions of municipality *i* within state *j* in year *j* by sector *m*

$SF_{i,j,k,m}$ is the scaling factor municipality *i* within state *j* in year *k* by sector *m*

$Emissions\_AEGIS_{j,k,m}$ is the refrigerant emissions of state *j* in year *k* for by *m*

6.1.6 Limitations and Considerations

None.

6.2 Industrial Processes

6.2.1 Approach

There are a range of large emitting facilities across Australia, which in some instances these emitters can be orders of magnitude higher than other sources of emissions within a municipality. Because of the scale of these emissions, they can significantly impact the total emissions for a municipality, and without being properly accounted for can lead to inflation of emission estimates for other municipalities without such facilities.

Therefore, industrial processes is modelled using a hybrid approach which incorporates key emitters, via the safeguard mechanism, and national level activity data which is apportioned to municipalities based on relevant scaling factors using jobs data. This ensures industrial processes emissions are complete whilst also ensuring location based key emitters are incorporated.

6.2.2 Included Categories

Scope 1 emissions from industrial processes within the boundary. Industrial processes include cement manufacturing, basic inorganic chemical manufacturing and primary metal and metal product manufacturing.

6.2.3 Base Data

Table 23: Industrial Processes Base Data

Availability	Description	Granularity	Source	Source ID
National	Jobs in the INDP level 4 category	Municipality	ABS	BMS-R7
National	State level stationary energy activity data by sector	State	Australian Energy Statistics	SE-R3
National	Safeguard Mechanism	Operator	Safeguard Mechanism	SE-R4
National	National Pollutants Inventory	Operator	National Pollutants Inventory	SE-R5
National	Industrial processes emissions	State	Australia's National Greenhouse Accounts	NGA-R1

6.2.4 Emissions Factors

There are no emissions factors since these are embedded in Australia's National Greenhouse Accounts industrial processes emissions. However, the industrial processes component of the key emitters uses the stationary energy emissions factors which are provided in Table 44, Table 45 and Table 46 of the Appendix. See Section 4.3.5 for more information.

6.2.5 Method IPPU_IP_T2_V1 - Key Emitters (Stage 1)

In Section 4.3.5 the proportion of industrial processes emissions component for key emitters via the safeguard mechanism are detailed in Equation 11. Therefore, the modelled industrial processes component for each key emitter can be calculated. Equation 36 shows the results.

Equation 36: Industrial Electricity Emissions for Safeguard Facilities

$$Emissions_{j,k,m,n} = P\_IP_{l,j,m} \times Emissions\_KEY_{l,j,m,n}$$

Where:

$Emissions_{j,k,m,n}$ is the industrial processes emissions for operation *n* within sector *m* within state *j* in year *k*

$P\_IP_{j,k,m}$ is the proportion of industrial processes emissions for state *j* in year *k* by sector *m*

$Emissions\_KEY_{j,k,m,n}$ is the safeguard emissions for operation *n* within sector *m* within state *j* in year *k*

6.2.6 Method IPPU_IP_T1_V1 - Modelled Data (Stage 2)

National level industrial processes emissions data, which is published by Australia's National Greenhouse Accounts (AEGIS), is available by five sectors. At this stage, not all emissions sources for industrial processes have been included. The determination has been if the source accounts for 5% or more of total industrial processes emissions. It should be noted that, even though emissions from a particular source may be below 5% it is possible that it may be more significant for specific regions. Table 24 shows the national AEGIS industrial processes emissions by sector in 2020.

Table 24: National AEGIS Industrial Processes Emissions, 2020

Sector	National Industrial Processes Emissions (Mt CO_2e)	Proportion National Industrial Processes Emissions (Mt CO_2e)	Included
Mineral Industry	5.2276	25.3%	Yes
Chemical Industry	4.7307	22.9%	Yes
Metal Industry	10.4872	50.8%	Yes
Non-Energy Products from Fuels and Solvent Use	0.1784	0.9%	No
Electronics Industry	Not Available		No

Therefore, industrial processes are limited to mineral industry, chemical industry and metal industry sectors. Also, mineral industry is limited to cement production and lime production, and chemical industry is limited to ammonia production and nitric acid production. These constraints are required since this data is scaled to the municipality level via jobs allocation and the jobs categories need to align well with industrial processes emissions categories. Table 25 shows the AEGIS categories for industrial processes and the corresponding scaling factors based on jobs allocation.

Table 25: Industrial Processes Category Concordances

AGEIS Sector	AGEIS subsector	Scaling Factor
Mineral Industry	Cement Production and Lime Production	Cement and Lime Manufacturing Jobs
Chemical Industry	Ammonia Production and Nitric acid Production	Basic Inorganic Chemical Manufacturing Jobs
Metal Industry	-	Primary Metal and Metal Product Manufacturing Jobs

Equation 37: Scaling Factors for Industrial Processes

$$SF_{i,j,k,CLM\_JOBS} = \frac{CLM\_JOBS_{i,j,k}}{\sum_i CLM\_JOBS_{i,j,k}}$$

$$SF_{i,j,k,BICM\_JOBS} = \frac{BICM\_JOBS_{i,j,k}}{\sum_i BICM\_JOBS_{i,j,k}}$$

$$SF_{i,j,k,PMMPM\_JOBS} = \frac{PMMPM\_JOBS_{i,j,k}}{\sum_i PMMPM\_JOBS_{i,j,k}}$$

Where:

$CLM\_JOBS_{i,j,k}$ is the number of cement and lime manufacturing jobs of municipality *i* within state *j* in year *k*

$BICM\_JOBS_{i,j,k}$ is the number of basic inorganic chemical manufacturing jobs of municipality *i* within state *j* in year *k*

$PMMPM\_JOBS_{i,j,k}$ is the number of primary metal and metal product manufacturing jobs of municipality *i* within state *j* in year *k*

The final stage is to integrate Australia's National Greenhouse Accounts industrial processes emissions by sector. Equation 38 shows the results.

Equation 38: Modelled Industrial Processes Emissions

$$Emissions\_MOD_{i,j,k,m} = Emissions\_AEGIS_{j,k,m} \times SF_{i,j,k,m}$$

Where:

$Emissions\_MOD_{i,j,k,m}$ is the modelled industrial processes emissions for municipality *i* in state *j* in year *k* by sector *m*

$Emissions\_AEGIS_{j,k,m}$ is the AEGIS industrial processes emissions for state *j* in year *k* by sector *m*

$SF_{i,j,k,m}$ is the scaling factor for municipality *i* in state *j* in year *k* for sector *m*

6.2.7 Method IPPU_IP_T12_V1 - Hybrid Approach (Stage 3)

The next stage is to integrate the key emitter data in Section 6.2.5 and modelled emissions in Section 6.2.6 to derive the industrial processes emissions for each municipality. It is important that key emitters industrial processes emissions and modelled industrial processes emissions for each municipality and sector sums to the industrial processes emissions data by sector state totals based on the Australian Energy Statistics which is published annually by the Department of Industry, Science, Energy and Resources. Therefore, the key emitters data is removed from the Australian Energy Statistics state totals for each sector and the remaining emissions are apportioned to each municipality based on jobs allocation. A correction factor is applied for each state, sector and year. Equation 39 shows results.

Equation 39: Correction Factor for Industrial Processes Emissions

$$CF_{j,k,m} = \frac{\left[\left(C \times Emissions\_AES_{j,k,m}\right) - \sum_i Emissions\_KEY_{i,j,k,m}\right]}{\sum_i Emissions\_MOD_{i,j,k,m}}$$

Where:

$CF_{i,j,m}$ is the correction factor for state *j* and year *k* for sector *m*

$Emissions\_AES_{j,k,m}$ is the industrial processes emissions based on the Australian Energy Statistics for state *j* and year *k* for sector *m*

$Emissions\_KEY_{i,j,k,m}$ is the key emitters industrial processes emissions for municipality *i* in state *j* and year *k* for sector *m*

$Emissions\_MOD_{i,j,k,m}$ is the modelled industrial processes emissions where the industrial processes emissions is less than the sum of the key emitters for municipality *i* in state *j* and year *k* for sector *m*

C = 277,777 is the conversion factor to convert GJ to KW

The final stage is to integrate the correction factor alongside the modelled industrial processes emissions for municipalities that have no key emitters data or where the key emitters data is less than the modelled state level data for each sector. Please note for municipalities where the key emitters data is higher than the modelled state level data for each sector the key emitters data is used. Equation 19 shows the results.

Equation 40: Industrial Processes Emissions

$$Emissions_{i,j,k,m} = \begin{cases} Emissions\_KEY_{i,j,k,m} & if\ Emissions\_KEY_{i,j,k,m} > Emissions_{i,j,k,m} \\ Emissions_{i,j,k,m} \times CF_{j,k,m} & if\ Emissions\_KEY_{i,j,k,m} < Emissions_{i,j,k,m} \end{cases}$$

Where:

$Emissions_{i,j,k,m}$ is the industrial processes emissions for municipality *i* within state *j* in year *k* by sector *m*

$Emissions\_KEY_{i,j,k,m}$ is the total industrial processes key emitters emissions municipality *i* within state j and year *k* by sector *m*

$CF_{j,k,m}$ is the correction factor for state *j* in year *k* by sector *m*

6.2.8 Limitations and Considerations

Due to data privacy issues with Australia's National Greenhouse Accounts industrial processes emissions data, this data is incorporated at a national level instead of a state level. There are likely to be idiosyncrasies within each state that impact industrial processes emissions above and beyond national jobs allocation.

A proportion of the key emitters emissions data via the Safeguard Mechanism is allocated to each of the electricity and industrial processes sectors. This allocation method uses data from Australian Energy Statistics and Australia's National Greenhouse Accounts to effectively derive an electricity ratio component at the state and sector level. However, the proportion of electricity and industrial process for each facility is likely to vary considerably even within each sector and state.

7. 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.

7.1 On Road Transport – Modelled Data

7.1.1 Approach

On Road transport is modelled based on vehicle registration data which is available at the municipality level by fuel type and is mapped against state-based fuel sales data to estimate on road transport emissions.

This methodology is applied to all municipalities prior to 2018 and post 2018 this methodology is applied to municipalities without google EIE transport data. Currently there are 169 municipalities with google EIE transport data which are predominantly inner-city municipalities with a population greater than 25,000. Therefore, this modelled approach for on road transport is applied to 368 municipalities nationwide without google EIE transport data.

7.1.2 Included Categories

This methodology includes all vehicle types but is limited to petrol and diesel fuel types. Scopes included are:

- Scope 1 emissions from transportation fuel sources
- Scope 3 emissions from the transmission and distribution of transportation energy sources

7.1.3 Base Data

Table 26: Modelled On Road Transport Base Data

Availability	Description	Granularity	Source	Source ID
National	Register of motor vehicles by LGA and fuel type	Municipality	Australian Bureau of Statistics	TRA-R2
National	Total fuel sales by fuel type	State	Australian Petroleum Statistics, Department of Climate Change, Energy, the Environment and Water	TRA-R3

7.1.4 Emissions Factors

This section uses fuel combustion emissions factors which are provided in Table 50 of the Appendix.

7.1.5 Method TR_OR_T1_V1 - Modelled Data

The state level fuel sales data is scaled to the municipality level based on the proportion of vehicle registrations by fuel type relative to the state. Equation 41 shows the scaling factors.

Equation 41: Fuel Sales Scaling Factor

$$SF_{i,j,k,m} = \frac{VEH_{i,j,k,m}}{\sum_i VEH_{i,j,k,m}}$$

Where

$SF_{i,j,k,m}$ is the scaling factor for municipality *i* within state *j* in year *k* by fuel type *m*

$VEH_{i,j,k,m}$ is the total registered vehicles for municipality *i* in state *j* in year *k* by fuel type *m*

The next stage is to derive the fuel sales activity data for each fuel type at the municipality level. Equation 42 shows the results.

Equation 42: Fuel Sales On Road Transport Activity Data Calculations

$$AD_{i,j,k,m} = SF_{i,j,k,m} \times FUEL_{j,k,m}$$

Where

$AD_{i,j,k,m}$ is modelled fuel sales activity data for municipality *i* in state *j* in year *k* for fuel type *m*

$SF_{i,j,k,m}$ is the scaling factor for municipality *i* within state *j* in year *k* for fuel type *m*

$FUEL_{j,k,m}$ is the total fuel sales for state *j* in year *k* for fuel type *m*

The final stage is to integrate the activity data, emissions factors and energy content factors to derive the on road emissions for each fuel type at the municipality level. Equation 43 shows the results.

Equation 43: Modelled On Road Emissions

$$Emissions_{i,j,k,m} = \sum_g \left(AD_{i,j,k,m} \times EC_m \times EF_{m,g} \times FE_{m,g}\right)$$

Where

$Emissions_{i,j,k,m}$ is the modelled on road transport emissions for municipality *i* within state j in year *k* for fuel type *m*

$AD_{i,j,k,m}$ is the modelled fuel sales activity data for municipality i within state *j* in year *k* for fuel type *m*

EC_m is the energy content factor for fuel type *m*

$EF_{m,g}$ is the emissions factor for fuel type *m* and gas type *g*

7.1.6 Limitations and Considerations

This approach assumes registered motor vehicles are a good approximation for vehicles that are currently in use. Furthermore, this approach assumes that vehicle usage is constant relative to vehicle registrations within each state.

7.2 On Road Transport – Google EIE Data

7.2.1 Approach

This method utilises Google EIE activity data aggregated to the municipal boundary, and then applies a series of functions to convert this to estimated emissions. The activity data represents kilometres travelled for trips that are wholly within the municipal boundary (Scope 1) and trips that begin or end within the municipality boundary but not both (Scope 3). This method set is identified as 'City-induced activity' by the GPC. See Figure 2.

Google EIE data is only available for municipalities which meet certain privacy thresholds including, but not limited to, having a population more than 25,000. Google EIE data is currently available for 169 municipalities nationally from 2018 onwards.

Google EIE data includes total distance by boundary (inbound, outbound and inboundary) and by transport mode including automobiles, motorcycles, rail, tram, bus, walking and cycling. This section is limited to automobiles, motorcycles and bus.

Figure 2: GPC Methods for On Road Transport

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

7.2.2 Included Categories

This methodology is limited to automobiles, buses and motorcycles and incorporates all fuel types including petrol, diesel, hybrid, hydrogen, LPG and EV. Please note automobiles is defined as passenger vehicles only and excludes medium and heavy vehicles. See Section 7.2.6 for more details. Scopes included are:

- Scope 1 emissions from transportation fuel sources
- Scope 3 emissions from intra boundary transportation
- Scope 3 emissions from the transmission and distribution of transportation energy sources

7.2.3 Base Data

Table 27: EIE On Road Transport Base Data

Availability	Description	Granularity	Source	Source ID
NSW	NSW Vehicle registrations by vehicle type and fuel type	State	Transport for NSW	TRA-R4
Specific municipalities nationally	Activity data (total distance) by transport mode and boundary type	Municipality	Google EIE	TRA-R5

7.2.4 Emissions Factors

This section uses fuel combustion emissions factors and fuel efficiency metrics by vehicle type which are both provided in Table 50 and Table 51 of the Appendix respectively.

7.2.5 Method TR_OR_T2_V1 – Local Activity Data

The EIE activity data for total distance travelled for each municipality is derived by aggregating the distance travelled for varying boundary types. Inbound and outbound data is multiplied by 50% for completeness and to avoid double counting. Equation 44 shows the results.

Equation 44: Total distance travelled

$$DIST_{i,j,m} = DIST_{i,j,m,inboundary} + 0.5 \times \left(DIST_{i,j,m,inbound} + DIST_{i,j,m,outbound}\right)$$

Where:

$DIST_{i,j,m}$ is the total distance for municipality *i* in year *j* for transport mode *m*

$DIST_{i,j,m,b}$ is the distance for municipality *i* in year *j* for transport mode *m* and boundary *b*

The next stage is to breakdown the total distance travelled for each transport mode (automobiles, motorcycles and buses) by fuel type. Equation 45 shows the scaling function to covert total distance by fuel type and vehicle type. This data is not currently freely available at the municipality level and thus state level data for NSW is used nationally.

Equation 45: Scaling function for fuel type and transport mode

$$SF_{f,j,m} = \frac{VEH_{f,j,m}}{\sum_f VEH_{f,j,m}}$$

Where

$SF_{f,j,m}$ is the scaling factor for fuel type *f* in year *j* by transport mode *m*

$VEH_{f,j,m}$ is the total registered vehicles in NSW for fuel type *f* in year *j* by transport mode *m*

This scaling function is used to derive the total distance activity data by fuel type and vehicle type. Equation 46 shows the results.

Equation 46: EIE On Road Transport activity data calculations

$$\boldsymbol{AD_{i,j,f,m} = SF_{f,j,m} \times DIST_{i,j,m}}$$

Where:

$AD_{i,j,f,m}$ is the EIE on road activity data for municipality *i* in year *j* for fuel type *f* by transport mode *m*

$SF_{f,j,m}$ is the scaling factor for fuel type *f* in year *j* by transport mode *m*

$DIST_{i,j,m}$ is the total distance for municipality i in year *j* for transport mode *m*

The final stage is to integrate the EIE activity data, fuel efficiency, emissions factors and energy content factors to derive the EIE on road emissions for each fuel type at the municipality level. Equation 47 shows the results.

Equation 47: EIE On Road Emissions

$$Emissions_{i,j,f,m} = \sum_g \left(AD_{i,j,f,m} \times EC_f \times EF_{f,g} \times FE_{f,m}\right)$$

Where

$Emissions_{i,j,f,m}$ is the total emissions for municipality *i* in year *j* for fuel type *f* and transport mode *m*

$AD_{i,j,f,m}$ is the EIE activity data for municipality i in year *j* for fuel type *f* and transport mode *m*

EC_f is the energy content factor for fuel type *f*

$EF_{f,g}$ is the emissions factor for fuel type *f and gas type* g

$FE_{f,m}$ is the fuel efficiency for fuel type *f* and transport mode *m*

7.2.6 Limitations and Considerations

This approach is limited to automobiles (passenger vehicles), buses and motorcycles and doesn't incorporate medium and heavy use vehicles. State level EIE data specifically for automobiles has been matched against external emissions data sets including AEGIS and it is apparent that the automobiles EIE data is limited to passenger vehicles and excludes medium and heavy vehicles. Section 7.3 accounts for this exclusion.

There are privacy constraints around whether a municipality has EIE data but there are additional privacy constraints at the sector and boundary level for a specific transport mode for each municipality. For example, there are instances where EIE data, specifically for all transport modes outside of automobiles, is present one year and absent another year (i.e. bus data for a municipality is non-zero pre-covid in 2018 and 2019 but it is zero in 2020 and 2021 due to privacy thresholds).

7.3 On Road Freight

7.3.1 Approach

This method is limited to municipalities with EIE data since the EIE automobile category is limited to passenger vehicles and excludes on road freight. Therefore, on road freight at the municipality level is calculated by integrating on road freight vehicle registration data alongside Australia's National Greenhouse Accounts emissions data to derive on road freight emissions.

7.3.2 Included Categories

This methodology is limited to medium and heavy-duty trucks. These include light rigid trucks, heavy rigid trucks, articulated trucks and non-freight carrying trucks.

- Scope 1 emissions from transportation fuel sources
- Scope 3 emissions from the transmission and distribution of transportation energy sources

7.3.3 Base Data

Table 28: On Road Freight Transport Base Data

Availability	Description	Granularity	Source	Source ID
National	Register of motor vehicles by LGA and vehicle type	Municipality	Australian Bureau of Statistics	TRA-R1
National	Medium and heavy-duty vehicle emissions	State	Australia's National Greenhouse Accounts	NGA-R1

7.3.4 Emissions Factors

There are no emissions factors since these are embedded in Australia's National Greenhouse Accounts medium and heavy duty on road transport emissions.

7.3.5 Method TR_ORF_T1_V1 - Modelled Data

Australia's National Greenhouse Accounts provide state level on road emissions data for, but not limited to, Buses, Medium Duty Trucks and Heavy-Duty Trucks. Since EIE have a separate category for Buses these are excluded and the state emissions for Medium Duty Trucks and Heavy-Duty Trucks are aggregated for each year. These are apportioned to the municipality level based on the proportion of vehicle registrations of trucks which include light rigid trucks, heavy rigid trucks, articulated trucks and non-freight carrying trucks relative to the state. Equation 48 shows the results.

Equation 48: On Road Freight Emissions for Municipalities with EIE Data

$$Emissions_{i,j,k} = Emissions\_AEGIS_{j,k} \times \frac{H\_VEH_{i,j,k}}{\sum_i H\_VEH_{i,j,j}}$$

Where

$Emissions_{i,j,k}$ is the total emissions for municipality *i* within state *j* in year *k*

$Emissions\_AEGIS_{j,k}$ is the medium and heavy-duty emissions (AEGIS) for state *j* in year *k*

$H\_VEH_{i,j,k}$ is the total number of heavy vehicles for municipality *i* within state *j* in year k

7.3.6 Limitations and Considerations

This approach assumes registered motor vehicles are a good approximation for vehicles that are currently in use. Furthermore, this approach assumes that vehicle usage is constant relative to vehicle registrations within each state.

7.4 Rail Transport

7.4.1 Approach

This method utilises Google EIE activity data aggregated to the municipal boundary, and then applies a series of functions to convert this to estimated emissions. The activity data represents kilometres travelled for trips that are wholly within the municipal boundary (Scope 1) and trips that begin or end within the municipality boundary but not both (Scope 3). This method set is identified as 'City-induced activity' by the GPC. See Figure 2 in Section 7.2.1.

Google EIE data is only available for municipalities which meet certain privacy thresholds including, but not limited to, having a population more than 25,000. Google EIE data is currently available for 169 municipalities nationally from 2018 onwards.

Google EIE data includes total distance by boundary (inbound, outbound and inboundary) and by transport mode including automobiles, motorcycles, rail, tram, bus, walking and cycling. This section is limited to rail.

7.4.2 Included Categories

This methodology is limited to rail, specifically passenger rail, and excludes rail freight. Scopes included are:

- Scope 1 emissions from rail fuel sources
- Scope 2 emissions from rail electricity sources
- Scope 3 emissions from intra boundary transportation
- Scope 3 emissions from the transmission and distribution of transportation energy sources

7.4.3 Base Data

Table 29: EIE Rail Transport Base Data

Availability	Description	Granularity	Source	Source ID
Specific municipalities nationally	Activity data (total distance) by transport mode and boundary type	Municipality	Google EIE	TRA-R5

7.4.4 Emissions Factors

This section uses emissions intensity factors for rail which are provided in Table 52 of the Appendix.

7.4.5 Method TR_RL_T2_V1 - Local Activity Data

The EIE activity data for total distance travelled for each municipality is derived by aggregating the distance travelled for varying boundary types. Inbound and outbound data is multiplied by 50% for completeness and to avoid double counting. See Equation 44 in Section 7.2.5 for further details.

The EIE activity data for rail is integrated with the emissions intensity and conversion factors to derive the municipality level emissions. Equation 49 shows the results.

Equation 49: EIE Rail Emissions

$$Emissions_{i,j,k} = AD_{i,j,k} \times EF_{m,g} \times C$$

Where

$Emissions_{i,j,k}$ is the modelled rail emissions for municipality i within state j in year k

$AD_{i,j,k}$ is the EIE rail activity data for municipality i within state j in year k

EF is the emissions intensity factor

C equals 0.001 the conversion factor

7.4.6 Limitations and Considerations

This approach is limited to passenger rail and excludes rail freight.

There are privacy constraints around whether a municipality has EIE data but there are additional privacy constraints at the sector and boundary level for a specific transport mode for each municipality. For example, there are instances where EIE data, specifically for all transport modes outside of automobiles, where it is present one year and absent another year (i.e. rail data for a municipality is non-zero pre-covid in 2018 and 2019 but it is zero in 2020 and 2021 due to privacy thresholds).

7.5 Tram Transport

7.5.1 Approach

This method utilises Google EIE activity data aggregated to the municipal boundary, and then applies a series of functions to convert this to estimated emissions. The activity data represents kilometres travelled for trips that are wholly within the municipal boundary (Scope 1) and trips that begin or end within the municipality boundary but not both (Scope 3). This method set is identified as 'City-induced activity' by the GPC. See Figure 2 in Section 7.2.1.

Google EIE data is only available for municipalities which meet certain privacy thresholds including, but not limited to, having a population more than 25,000. Google EIE data is currently available for 169 municipalities nationally from 2018 onwards.

Google EIE data includes total distance by boundary (inbound, outbound and inboundary) and by transport mode including automobiles, motorcycles, rail, tram, bus, walking and cycling. This section is limited to trams.

7.5.2 Included Categories

This methodology is limited to trams. Scope included are:

- Scope 2 emissions from tram electricity sources
- Scope 3 emissions from intra boundary transportation
- Scope 3 emissions from the transmission and distribution of tram energy sources

7.5.3 Base Data

Table 30: EIE Tram Transport Base Data

Availability	Description	Granularity	Source	Source ID
Specific municipalities nationally	Activity data (total distance) by transport mode and boundary type	Municipality	Google EIE	TRA-R4

7.5.4 Emissions Factors

This section uses energy efficiency factors for tram (Table 53) and grid electricity scope factors (Table 45) which are both provided in the Appendix.

7.5.5 Method TR_TM_T2_V1 - Local Activity Data

The EIE activity data for total distance travelled for each municipality is derived by aggregating the distance travelled for varying boundary types. Inbound and outbound data is multiplied by 50% for completeness and to avoid double counting. See Equation 44 in Section 7.2.5 for further details.

The EIE activity data for tram is integrated with the emissions factors, energy efficiency factors and conversion factors to derive the municipality level emissions. Equation 50 shows the results.

Equation 50: EIE Tram Emissions

$$Emissions_{i,j,k} = \sum_{l=2,3} \left(AD_{i,j,k} \times EF_{j,k,l} \times EE \times C\right)$$

Where

$Emissions_{i,j,k}$ is the modelled tram emissions for municipality *i* in state *j* in year *k*

$AD_{i,j,k}$ is the EIE tram activity data for municipality *i* in state *j* in year *k*

$EF_{j,k,l}$ is the emissions factor for state *j* in year *k* for scope *l*

EE is the energy efficiency factor

C equals 0.001 the conversion factor

7.5.6 Limitations and Considerations

There are privacy constraints around whether a municipality has EIE data but there are additional privacy constraints at the sector and boundary level for a specific transport mode for each municipality. For example, there are instances where EIE data, specifically for all transport modes outside of automobiles, where it is present one year and absent another year (i.e. tram data for a municipality is non-zero pre-covid in 2018 and 2019 but it is zero in 2020 and 2021 due to privacy thresholds).

7.6 Aviation Transport

7.6.1 Approach

Aviation transport emissions is modelled by integrating aviation data between the top routes in Australia and a larger number of regional airports. The aviation data for the top routes is monthly data which includes the airport codes of origin and destination, number of passengers and trips as well as the distance between the two airports. There are 41 airports included in this data set.

Also, a larger number of regional airports are included by integrating a separate data set which includes 92 airports and once the main 41 airports are excluded there are an additional 51 regional airports or 92 airports in total. Six regional airports are excluded since they are not part of any Australian municipality leaving 86 airports in total. This regional data set is also monthly but is limited to the total number of trips per airport. The destinations of regional airports were manually extracted via Wikipedia.

7.6.2 Included Categories

This methodology includes 86 airports of which 41 are considered main airports and 45 regional airports. Data is limited to domestic flights and excludes air freight. Table 31 shows the 41 main airports and their corresponding municipality. Scopes included are:

- Scope 1 emissions from aviation fuel sources
- Scope 3 emissions from intra boundary transportation
- Scope 3 emissions from the transmission and distribution of transportation energy sources

Table 31: Main Airport Lookup

Airport Code	State	Municipality	Airport Code	State	Municipality
CBR	ACT	Unincorporated ACT	EMD	QLD	Central Highlands
ABX	NSW	Albury	GLT	QLD	Gladstone
ARM	NSW	Armidale Dumaresq	ISA	QLD	Mount Isa
CFS	NSW	Coffs Harbour	MKY	QLD	Mackay
DBO	NSW	Dubbo	MOV	QLD	Isaac
NTL	NSW	Port Stephens	ROK	QLD	Rockhampton
PQQ	NSW	Port Macquarie-Hastings	TSV	QLD	Townsville
QNA	NSW	Ballina	ADL	SA	West Torrens
SYD	NSW	Bayside	PLO	SA	Lower Eyre Peninsula
TMW	NSW	Tamworth Regional	HBA	TAS	Clarence
WGA	NSW	Wagga Wagga	LST	TAS	Northern Midlands
ASP	NT	Alice Springs	MEL	VIC	Hume

AYQ	NT	Macdonnell	MQL	VIC	Mildura
DRW	NT	Darwin	BME	WA	Broome
BDB	QLD	Bundaberg	GET	WA	Greater Geraldton
BNE	QLD	Brisbane	KGI	WA	Kalgoorlie-Boulder
CNS	QLD	Cairns	KTA	WA	Karratha
HTI	QLD	Whitsunday	PER	WA	Belmont
MCY	QLD	Sunshine Coast	PHE	WA	Port Hedland
OOL	QLD	Gold Coast	ZNE	WA	East Pilbara
PPP	QLD	Whitsunday			

Table 32 shows the 45 regional airports and their corresponding municipality.

Table 32: Regional Airport Lookup

Airport Code	State	Municipality	Airport Code	State	Municipality
BHQ	NSW	Broken Hill	ONG	QLD	Mornington
GFF	NSW	Griffith	PMK	QLD	Palm Island
MIM	NSW	Bega Valley	RMA	QLD	Maranoa
MRZ	NSW	Moree Plains	WEI	QLD	Cook
MYA	NSW	Eurbodalla	WTB	QLD	Toowoomba
OAG	NSW	Orange	CED	QLD	Ceduna
WOL	NSW	Shellharbour	KGC	QLD	Kangaroo Island
ELC	NT	East Arnhem	MGB	QLD	Grant
GOV	NT	East Arnhem	OLP	QLD	Roxby Downs
MNG	NT	West Arnhem	WYA	QLD	Whyalla
ABM	QLD	Northern Peninsula	BWT	TAS	Waratah/Wynyard
AUU	QLD	Aurukun	DPO	TAS	Devonport
CNJ	QLD	Cloncurry	FLS	TAS	Flinders
CTL	QLD	Murweh	KNS	TAS	King Island
CTN	QLD	Cook	MEB	TAS	Moonee Valley
DMD	QLD	Doomadgee	ALH	WA	Albany
EDR	QLD	Pormpuraaw	CVQ	WA	Carnarvon
HID	QLD	Torres	EPR	WA	Esperance
HVB	QLD	Fraser Coast	KNX	WA	Wyndham-East Kimberley
IRG	QLD	Lockhart River	LEA	WA	Exmouth

KUG	QLD	Torres Strait Island		ONS	WA	Ashburton
KWM	QLD	Kowanyama		PBO	WA	Ashburton
LRE	QLD	Longreach				

7.6.3 Base Data

Table 33: Aviation Transport Base Data

Availability	Description	Granularity	Source	Source ID
National	Australian Domestic Airline Activity – Time Series	Airport x Airport	BITRE	TRA-R5
National	Airport Traffic Data	Airport	BITRE	TRA-R6
National	ICAO Carbon Emissions Calculator	Airport x Airport	ICAO	TRA-R7

7.6.4 Emissions Factors

This section uses fuel combustion emissions factors which are provided in Table 49 of the Appendix.

7.6.5 Method TR_AV_T2_V1 - Local Activity Data

A robust method is used to approximate the aircraft fuel burn for each journey using simple linear regression based on the distance between airports and approximate aircraft fuel burn for each journey between the major cities across Australia. The aircraft fuel burn per trip for all combinations of the major cities is derived from the ICAO Carbon Emissions Calculator. This is applied to main and regional airports to estimate the aircraft fuel burn for each flight. Since the distance is unknown for the 51 regional airports a manual process is undertaken by researching the main destinations of these airports and deriving the total distance across all destinations. Table 34 shows results of the regression analysis.

Table 34: Regression Analysis for Estimating Aircraft Fuel Burn

Variable	Coefficient	R^2
Constant	1317.876	0.926
Distance	3.658	-

The results suggest the model is an excellent fit for estimating the aircraft fuel burn since 92.6% of the variation is explained by distance between airports. The next stage is to derive the total estimated aircraft fuel burn activity data for each municipality by integrating the total trips for each airport within Australia alongside the estimate aircraft fuel burn for each flight.

Equation 51: Total estimated aircraft fuel burn

$$AD_{i,j,k} = \sum_{m,n} \{TRIPS_{m,n,i,k} \times [1318 + (3.658 \times DIST_{m,n,i})] \times C\}$$

Where

$AD_{i,j,k}$ is the estimated total aircraft fuel burn for municipality *i* within state *j* in year *k*

$TRIPS_{m,n,i,k}$ is the total number of trips between airport *m* and airport *n* within municipality *i* in year *j*

$DIST_{m,n,i}$ is the distance between airport *m* and airport *n* within municipality *i*

C equals 0.78 which is a conversion factor

The final stage is to multiply the activity data by the emissions factors and energy content factors to derive the total aviation emissions at the municipality level. Equation 52 shows the results.

Equation 52: Aviation Emissions

$$Emissions_{i,j,k} = \sum_g (AD_{i,j,k} \times EF_g \times EC \times C)$$

Where

$Emissions_{i,j,k}$ is the emissions for municipality *i* within state *j* in year *k*

$AD_{i,j,k}$ is the estimated total aircraft fuel burn activity data for municipality *i* within state *j* in year *k*

EF_g is the emissions factor for gas type *g*

EC is the energy content factor

C equals 0.000001 is the conversion factor

7.6.6 Limitations and Considerations

This approach is limited domestic flights including the top routes in Australia and a number of regional airports. Therefore, several minor regional airports are excluded due to data availability.

8. 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.

8.1 Solid Waste

8.1.1 Approach

This method takes data from the Waste generation and resource recovery in Australia, a study developed by Randall Environmental Consulting which breaks down solid waste generation by sector and state. This is integrated with Australia's National Greenhouse Accounts solid waste emissions data (AEGIS) and alongside relevant scaling factors is used to derive solid waste emissions by sector at the municipality level.

8.1.2 Included Categories

Solid waste includes residential, commercial and industrial, and construction and demolition sectors. Scopes included are:

- Scope 1 emissions from waste sources (excluding emissions from imported waste)
- Scope 3 emissions from waste generated within the boundary and exported for treatment

8.1.3 Base Data

Table 35: Solid Waste Base Data

Availability	Description	Granularity	Source	Source ID
National	Solid Waste by Sector	State	Randell Consulting	WST-R1
National	Managed waste disposal sites	State	Australia's National Greenhouse Accounts (AEGIS)	NGA-R1
National	Population	Municipality	Australian Bureau of Statistics	BMS-R1
National	Commercial Jobs and Building Approvals	Municipality	Economic Indicators	BMS-R8

8.1.4 Emissions Factors

There are no emissions factors since these are embedded in Australia's National Greenhouse Accounts solid waste emissions.

8.1.5 Method WS_SW_T1_V1 - Modelled Data

State level solid waste generation data by sector, which is published by Randall Consulting, is scaled using relevant factors to represent waste generation for the municipality. For the residential sector, solid waste generation is scaled by the ratio of population of municipality relative to the state. For the commercial and industrial sector, solid waste generation is scaled by the ratio of commercial jobs of municipality relative to the state. For the construction and demolition sector, solid waste generation is scaled by the ratio of building approvals of municipality relative to the state. Equation 53 shows the results.

Equation 53: Scaling factors for solid waste

$$SF_{i,j,k,RES} = \frac{POP_{i,j,k}}{\sum_i POP_{i,j,k}}$$

$$SF_{i,j,k,COM\_IND} = \frac{C\_JOBS_{i,j,k}}{\sum_i C\_JOBS_{i,j,k}}$$

$$SF_{i,j,k,CON\_DEM} = \frac{BLD\_APR_{i,j,k}}{\sum_i BLD\_APR_{i,j,k}}$$

Where:

$SF_{i,j,k,m}$ is the scaling factor for municipality *i* within state *j* in year *k* by sector *m*

$POP_{i,j,k}$ is the population for municipality *i* within state *j* in year *k*

$C\_JOBS_{i,j,k}$ is the number for commercial jobs for municipality *i* within state *j* in year *k*

$BLD\_APR_{i,j,k}$ is the number for building approvals for municipality *i* within state *j* in year *j*

The next step is to derive the proportion of solid waste generation by state and sector. This step is necessary since Australia's National Greenhouse Accounts solid waste emissions data is aggregated for all sectors. Equation 54 shows the results.

Equation 54: Proportion of Solid Waste Generation by State and Sector

$$P\_SWG_{j,k,m} = \frac{SWG_{j,k,m}}{\sum_m SWG_{j,k,m}}$$

Where:

$P\_SWG_{j,k,m}$ is the proportion solid waste generation for state *j* in year *k* by sector *m* relative to all sectors

$SWG_{j,k,m}$ is the solid waste generation for state *j* in year *k* by sector *m*

The final step is to integrate Australia's National Greenhouse Accounts solid waste emissions by state and sector. Equation 55 shows the results.

Equation 55: Solid Waste Emissions

$$Emissions_{i,j,k,m} = Emissions\_AEGIS_{j,k} \times SF_{i,j,k,m} \times P\_SWG_{j,k,m}$$

Where:

$Emissions_{i,j,k,m}$ is the modelled solid waste emissions for municipality *i* within state *j* in year *k* for sector *m*

$Emissions\_AEGIS_{j,k}$ is the AEGIS solid waste emissions for state *j* in year *k*

$SF_{i,j,k,m}$ is the scaling factor for municipality *i* within state *j* in year *k* for sector *m*

$P\_SWG_{j,k,m}$ is the proportion of solid waste generation for state *j* in year *k* for sector *m* relative to all sectors

8.1.6 Limitations 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.

This method assumes that treatment of waste is consistent with the categorizations of the NGERS standard

8.2 Wastewater

8.2.1 Approach

This method takes data from Australia's National Greenhouse Accounts and is integrated alongside relevant scaling factors to derive solid waste emissions by sector at the municipality level.

8.2.2 Included Categories

Wastewater includes residential and industrial sectors. Scopes included are:

- Scope 1 emissions from waste sources (excluding emissions from imported waste)
- Scope 3 emissions from waste generated within the boundary and exported for treatment

8.2.3 Base Data

Table 36: Wastewater Base Data

Availability	Description	Granularity	Source	Source ID
National	Wastewater treatment and discharge	State	Australia's National Greenhouse Accounts (AEGIS)	NGA-R1
National	Population	Municipality	Australian Bureau of Statistics	BMS-R1
National	Jobs in the INDP level 1 category	Municipality	Australian Bureau of Statistics	BMS-R4

8.2.4 Emissions Factors

There are no emissions factors since these are embedded in Australia's National Greenhouse Accounts wastewater emissions.

8.2.5 Method WS_WW_T1_V1 - Modelled Data

State level waste-water emissions data, which is published by Australia's National Greenhouse Accounts, is available by residential and industrial sectors. This data is scaled using relevant factors to represent wastewater for the municipality by sector. For the residential sector, wastewater is scaled by the ratio of population of municipality relative to the state. For the industrial sector, wastewater is scaled by the ratio of industrial jobs of municipality relative to the state. Equation 56 shows the results.

Equation 56: Scaling Factors for Wastewater

$$SF_{i,j,k,RES} = \frac{POP_{i,j,k}}{\sum_i POP_{i,j,k}}$$

$$SF_{i,j,k,IND} = \frac{I\_JOBS_{i,j,k}}{\sum_i I\_JOBS_{i,j,k}}$$

Where

$SF_{i,j,k,m}$ is the scaling factor for municipality *i* within state *j* in year *k* by sector *m*

$POP_{i,j,k}$ is the population of municipality *i* within state *j* in year *k*

$I\_JOBS_{i,j,k}$ is the number of industrial jobs for municipality *i* within state *j* in year *k*

The final step is to integrate the total wastewater emissions by state and sector. Equation 57 shows the results.

Equation 57: Wastewater emissions

$$Emissions_{i,j,k,m} = SF_{i,j,k,m} \times Emissions\_AEGIS_{j,k,m}$$

Where

$Emissions_{i,j,k,m}$ is the modelled wastewater emissions for municipality *i* within state *j* in year *k* by sector *m*

$SF_{i,j,k,m}$ is the scaling factor for municipality *i* within state *j* in year *k* by sector *m*

$Emissions\_AEGIS_{j,k,m}$ is the AGEIS wastewater emissions for state *j* in year *k* by sector *m*

8.2.6 Limitations 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.

9. 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 5% 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. Table 37 shows the national AEGIS agriculture emissions for 2020 by sector.

Table 37: National AEGIS Agriculture Emissions

Category	National Agriculture Emissions (Mt CO_2e)	Proportion of National Emissions	Included
Enteric Fermentation	11.5309	75.2%	Yes
Manure Management	1.1555	7.5%	Yes
Rice Cultivation	0.0198	0.1%	No
Agriculture Soils	2.0630	13.5%	Yes
Prescribed Burning of Savannas	Not Available		No
Field Burning of Agriculture Residues	0.0428	0.3%	No
Liming	0.2444	1.6%	No
Urea Application	0.2679	1.7%	No
Other Carbon-Containing Fertilisers	Not Available		No

9.1 Enteric Fermentation

9.1.1 Approach

This method uses the latest agriculture commodities activity data by local government area which became available in the second half of 2022. Temporal scaling is applied for previous years based on Australian Bureau of Statistics defined Statistical Area 4 (SA4) agriculture commodities data which is published annually and is normalised to the state total agriculture commodities data.

9.1.2 Included Categories

Enteric fermentation includes scope 1 emissions from dairy cattle, non-dairy cattle, sheep/lambs and pigs.

9.1.3 Base Data

Table 38: Enteric Fermentation Base Data

Availability	Description	Granularity	Source	Source ID
National	Agriculture Commodities	Municipality	Australian Bureau of Statistics	AGR-R1
National	Agriculture Commodities	SA4	Australian Bureau of Statistics	AGR-R2
National	Agriculture Commodities	State	Australian Bureau of Statistics	AGR-R3
National	Local Government Area Concordances	Municipality	Australian Bureau of Statistics	BMS-R9
National	SA4 Concordances	SA4	Australian Bureau of Statistics	BMS-R11

9.1.4 Emissions Factors

This section uses enteric fermentation emissions factors which are provided in Table 54 of the Appendix.

9.1.5 Method AG_EF_T2_V1 - Local Activity Data

The municipality agriculture commodities activity data set is only a recent publication by the Australian Bureau of Statistics and is only available for the 2020/21 reporting period. Therefore, the first step is to apply temporal scaling for earlier years which is based on the SA4 agriculture commodities activity data which is published annually by the Australian Bureau of Statistics. Equation 58 shows the temporal scaling methodology which includes concordances between municipalities and SA4 regions. Constraints are placed on the ratio of SA4 agriculture commodities data in 2020/21 relative to earlier years due to large variances in some situations. These bounds include a lower bound of 0.2 (i.e. 20%) and an upper bound of 5 (i.e. 500%).

Equation 58: Temporal Scaling for Agriculture Commodities Activity Data

$$AD_{i,j,k,m} = \sum_{s} \left(INT_{i,s} \times \frac{AD\_SA4_{i,j,k,m,s}}{AD\_SA4_{i,j,2020/21,m,s}} \right)$$

Where

$AD_{i,j,k,m}$ is the agriculture commodities activity data for municipality *i* within state j in year *k* by sector *m*

$INT_{i,s}$ is the proportion of the land area of the municipality *i* within the intersection of municipality *i* and SA4 region *s*

$AD\_SA4_{i,j,k,m,s}$ is the SA4 agriculture commodities activity data for municipality i within SA4 region *s* and state *j* in year *k* by sector *m*

The next step is to ensure the modelled municipality activity data for earlier years prior to 2020/21 adds to the state agriculture commodities activity data for that year. Therefore, a scaling factor is applied. Equation 59 shows the results.

Equation 59: Agriculture Commodities State Scaling Factor

$$SF_{j,k,m} = \frac{AD\_State_{j,k,m}}{\sum_i AD_{i,j,k,m}}$$

Where

$SF_{j,k,m}$ is the scaling factor for agriculture commodities for state *j* in year *k* by sector *m*

$AD\_State_{j,k,m}$ is the state agriculture commodities activity data for state *j* in year *k* by sector *m*

$AD_{i,j,k,m}$ is the agriculture commodities activity data for municipality *i* within state *j* in year *k* by sector *m*

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 uses agriculture commodities activity data at the municipality level provided by the Australian Bureau of Statistics and is multiplied by relevant emissions factors and conversion factors. Equation 60 shows the results.

Equation 60: Enteric Fermentation Emissions

$$Emissions_{i,j,k,m} = AD_{i,j,k,m} \times SF_{j,k,m} \times EF_m \times C$$

Where

$Emissions_{i,j,k,m}$ is the enteric fermentation agriculture emissions for municipality *i* within state *j* in year *k* by sector *m*

$AD_{i,j,k,m}$ is the agriculture commodities activity data for municipality *i* within state *j* in year *k* by sector *m*

$SF_{j,k,m}$ is the agriculture commodities scaling factor for state *j* in year *k* by sector *m*

EF_m is the emissions factor for sector m

C is 0.028 which is the conversion factor

9.1.6 Limitations and Considerations

None.

9.2 Manure Management

9.2.1 Approach

This method uses the latest agriculture commodities activity data by local government area which became available in the second half of 2022. Temporal scaling is applied for previous years based on Australian Bureau of Statistics defined Statistical Area 4 (SA4) agriculture commodities data which is published annually and is normalised to the state total agriculture commodities data.

9.2.2 Included Categories

Manure management includes dairy cattle, non-dairy cattle, sheep/lambs, pigs and live poultry.

9.2.3 Base Data

Table 39: Manure Management Base Data

Availability	Description	Granularity	Source	Source ID
National	Agriculture Commodities	Municipality	Australian Bureau of Statistics	AGR-R1
National	Agriculture Commodities	SA4	Australian Bureau of Statistics	AGR-R1
National	Agriculture Commodities	State	Australian Bureau of Statistics	AGR-R1
National	Local Government Area Concordances	Municipality	Australian Bureau of Statistics	BMS-R9
National	SA4 Concordances	SA4	Australian Bureau of Statistics	BMS-R11

9.2.4 Emissions Factors

This section uses manure management emissions factors which are provided in Table 55 of the Appendix. Please note where there is a range of emissions factors within each temperature band, a conservative approach of using the highest emissions factor in the calculations is taken.

The manure management emissions factors are dependent upon the climate within each region. Table 40 shows the climate for each state.

Table 40: Climate by State

State	Climate		State	Climate
NSW	Warm		NT	Warm
QLD	Warm		VIC	Temp
SA	Warm		TAS	Cool
WA	Warm			

9.2.5 Method AG_MM_T2_V1 - Local Activity Data

Identical to Section 9.1.5, the agriculture commodities data is temporally scaled according to Equation 58 and normalised to the state totals according to Equation 59 and is determined using the Tier 1 calculation method from the IPCC Emissions Calculations Guidelines.

This method uses agriculture commodities activity data at the municipality level provided by the Australian Bureau of Statistics and is multiplied by relevant emissions factors and conversion factors. Equation 61 shows the results.

Equation 61: Manure Management Emissions

$$Emissions_{i,j,k,m} = AD_{i,j,k,m} \times SF_{j,k,m} \times EF_m \times C$$

Where

$Emissions_{i,j,k,m}$ is the manure management agriculture emissions for municipality *i* within state *j* in year *k* by sector *m*

$AD_{i,j,k,m}$ is the agriculture commodities activity data for municipality *i* within state *j* in year *k* by sector *m*

$SF_{j,k,m}$ is the agriculture commodities scaling factor for state *j* in year *k* by sector *m*

EF_m is the emissions factor for sector m

C is 0.028 which is the conversion factor

9.2.6 Limitations and Considerations

None.

9.3 Agriculture Soils

9.3.1 Approach

This method uses the latest agriculture commodities activity data by local government area which became available in the second half of 2022. Temporal scaling is applied for previous years based on Australian Bureau of Statistics defined Statistical Area 4 (SA4) agriculture commodities data which is published annually and is normalised to the state total agriculture commodities data.

9.3.2 Included Categories

Agriculture soils includes cotton, sugar cane, vegetables, hay/silage, rice and other broadacre crops.

9.3.3 Base Data

Table 41: Agriculture Soils Base Data

Availability	Description	Granularity	Source	Source ID
National	Agriculture Commodities	Municipality	Australian Bureau of Statistics	AGR-R1
National	Agriculture Commodities	SA4	Australian Bureau of Statistics	AGR-R2
National	Agriculture Commodities	State	Australian Bureau of Statistics	AGR-R3
National	Local Government Area Concordances	Municipality	Australian Bureau of Statistics	BMS-R9
National	SA4 Concordances	SA4	Australian Bureau of Statistics	BMS-R11

9.3.4 Emissions Factors

The agriculture soils emissions factors and conversion factors have been developed internally and are a composite of several references. For more information on the agricultural soils emissions factors and the assumptions employed please contact Ironbark at hello@snapshotclimate.com.au.

9.3.5 Method AG_AS_T2_V1 - Local Activity Data

Identical to Section 9.1.5, the agriculture commodities data is temporally scaled according to Equation 58 and normalised to the state totals according to Equation 59 and is determined using the Tier 1 calculation method from the IPCC Emissions Calculations Guidelines.

This method uses agriculture commodities activity data at the municipality level provided by the Australian Bureau of Statistics and is multiplied by relevant synthesized emissions factors and conversion factors. Equation 62 shows the results.

Equation 62: Agriculture Soils Emissions

$$Emissions_{i,j,k,m} = AD_{i,j,k,m} \times SF_{j,k,m} \times EF_m \times C$$

Where

$Emissions_{i,j,m}$ is the agriculture soils emissions for municipality *i* within state *j* in year *k* by sector *m*

$AD_{i,j,k,m}$ is the agriculture commodities activity data for municipality *i* within state *j* in year *k* by sector *m*

$SF_{j,k,m}$ is the agriculture commodities scaling factor for state *j* in year *k* by sector *m*

EF_m is the emissions factor for sector m

C is the state and sector specific conversion factor

Please note the conversion factor, similar to the emissions factors for agriculture soils, are highly synthesized at the state and sector level and thus there is limited information available to share publicly.

9.3.6 Limitations and Considerations

The emissions associated with agriculture soils are based on highly synthesized emissions factors and conversion factors. Therefore, this method will be revisited when better data sources become available.

9.4 Land Clearing

9.4.1 Approach

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

Land use changes are not recorded at the municipality 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

9.4.2 Included Categories

This section is limited to scope 1 emissions from land clearing.

9.4.3 Base Data

Table 42: Land Use Base Data

Availability	Description	Granularity	Source	Source ID
National	Primary Conversion Area by kha	Bioregion (IBRA7)	Department of Environment and Energy	LU-R1
National	Re-clearing area by kha	Bioregion (IBRA7)	Department of Environment and Energy	LU-R2
National	Local Government Area Concordances	Municipality	Australian Bureau of Statistics	BMS-R9
National	Interim Biogeographic Regionalisation Concordances	Interim Biogeographic Regionalisation	Department of Environment and Energy	BMS-R12

9.4.4 Emissions Factors

The emissions factors used for land clearing are detailed in Section 9.4.5.

9.4.5 Method LU_LC_T1_V1 - Modelled 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). The next stage is to estimate the losses from primary conversion and re-clearing. Figure 3 shows the results.

Figure 3: Annual Carbon Losses in Biomass Due to Disturbances

EQUATION 2.14

ANNUAL CARBON LOSSES IN BIOMASS DUE TO DISTURBANCES

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

Where:

$L_{disturbances}$ = 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.

Figure 4 and Figure 5 shows the assumptions that were used to estimate the amount of embedded carbon in the forests being cleared (B_W). Further assumptions include the following:

- ‘Less than 20 years’ category is used for reclearing locations
- ‘Greater than 20 years’ category for primary conversion
- ‘Less than 50 tonnes’ category for reclearing losses
- ‘Greater than 50 years’ category for new conversion losses
- The fraction of biomass disturbs was assumed to be 1
- The carbon factor was assumed to be 0.5

Figure 4: Above-Ground Biomass in Forests

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

Figure 5: Ratio of Below-Ground Biomass to Above-Ground Biomass

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

9.4.6 Limitations 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.

9.5 Afforestation

9.5.1 Approach

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 municipality 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

9.5.2 Included Categories

This section is limited to scope 1 emissions from afforestation.

9.5.3 Base Data

Table 43: Land Use Base Data

Availability	Description	Granularity	Source	Source ID
National	Forest Regrowing by kha	Bioregion (IBRA7)	Department of Environment and Energy	LU-R3
National	Local Government Area Concordances	Municipality	Australian Bureau of Statistics	BMS-R9
National	Interim Biogeographic Regionalisation Concordances	Interim Biogeographic Regionalisation	Department of Environment and Energy	BMS-R12

9.5.4 Emissions Factors

The emissions factors used for afforestation are detailed in Section 9.5.5.

9.5.5 Method LU_AF_T1_V1 - Modelled 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). The next stage is to estimate gains from forest regrowing. This process involves converting tonnes of dry matter per Ha 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.

9.5.6 Limitations 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 modelling errors that can propagate to the total estimation.

Appendices

Appendix A - Methodology Overview by State

Table 44: Methodology overview by state

State	Sector	Subsector	Method
NSW	Electricity	Residential	SEE_RE_T1_V1 SEE_RE_T2_V1
		Commercial	SEE_CO_T1_V1 SEE_CO_T2_V1
		Industrial	SEE_IN_T1_V1 SEE_IN_T2_V1 SEE_IN_T12_V1
	Gas	Residential	SEG_RE_T1_V1 SEG_RE_T2_V1
		Commercial	SEG_CO_T1_V1
		Industrial	SEG_IN_T1_V1
	Transport	On Road	TR_OR_T1_V1 TR_OR_T2_V1 TR_ORF_T1_V1
		Rail	TR_RL_T2_V1
		Tram	TR_TM_T2_V1
		Aviation	TR_AV_T2_V1
	Waste	Solid Waste	WS_SW_T1_V1
		Wastewater	WS_WW_T1_V1
	IPPU	Industrial Product Use	IPPU_PU_T1_V1
		Industrial Processes	IPPU_IP_T1_V1 IPPU_IP_T2_V1 IPPU_IP_T12_V1
	AFOLU	Enteric Fermentation	AG_EF_T2_V1
		Manure Management	AG_MM_T2_V1
		Agricultural Soils	AG_AS_T2_V1
		Land Clearing	LU_LC_T1_V1
		Afforestation	LU_AF_T1_V1
Queensland	Electricity	Residential	SEE_RE_T2_V1
		Commercial	SEE_CO_T2_V1
		Industrial	SEE_IN_T1_V1 SEE_IN_T2_V1 SEE_IN_T12_V1
	Gas	Residential	SEG_RE_T1_V1
		Commercial	SEG_CO_T1_V1

		Industrial	SEG_IN_T1_V1
	Transport	On Road	TR_OR_T1_V1 TR_OR_T2_V1 TR_ORF_T1_V1
		Aviation	TR_AV_T2_V1
		Rail	TR_RL_T2_V1
		Tram	TR_TM_T2_V1
	Waste	Solid Waste	WS_SW_T1_V1
		Wastewater	WS_WW_T1_V1
	IPPU	Industrial Product Use	IPPU_PU_T1_V1
		Industrial Processes	IPPU_IP_T1_V1 IPPU_IP_T2_V1 IPPU_IP_T12_V1
	AFOLU	Enteric Fermentation	AG_EF_T2_V1
		Manure Management	AG_MM_T2_V1
		Agricultural Soils	AG_AS_T2_V1
		Land Clearing	LU_LC_T1_V1
		Afforestation	LU_AF_T1_V1
Victoria, Northern Territory, Western Australia, Tasmania, South Australia	Electricity	Residential	SEE_RE_T1_V1
		Commercial	SEE_CO_T1_V1
		Industrial	SEE_IN_T1_V1 SEE_IN_T2_V1 SEE_IN_T12_V1
	Gas	Residential	SEG_RE_T1_V1
		Commercial	SEG_CO_T1_V1
		Industrial	SEG_IN_T1_V1
	Transport	On Road	TR_OR_T1_V1 TR_OR_T2_V1 TR_ORF_T1_V1
		Aviation	TR_AV_T2_V1
		Rail	TR_RL_T2_V1
		Tram	TR_TM_T2_V1
	Waste	Solid Waste	WS_SW_T1_V1
		Wastewater	WS_WW_T1_V1
	IPPU	Industrial Product Use	IPPU_PU_T1_V1
		Industrial Processes	IPPU_IP_T1_V1 IPPU_IP_T2_V1 IPPU_IP_T12_V1
	AFOLU	Enteric Fermentation	AG_EF_T2_V1

		Manure Management	AG_MM_T2_V1
		Agricultural Soils	AG_AS_T2_V1
		Land Clearing	LU_LC_T1_V1
		Afforestation	LU_AF_T1_V1

Appendix B – Emissions Factor Lookup Tables

Table 45: Electricity Scope Factors

State	Year	Scope 2 Emissions Factor	Scope 3 Emissions Factor
NSW and ACT	2015/16	0.83	0.12
NSW and ACT	2016/17	0.82	0.10
NSW and ACT	2017/18	0.81	0.09
NSW and ACT	2018/19	0.79	0.08
VIC	2015/16	1.07	0.09
VIC	2016/17	1.07	0.10
VIC	2017/18	1.02	0.11
VIC	2018/19	0.96	0.10
QLD	2015/16	0.79	0.14
QLD	2016/17	0.80	0.13
QLD	2017/18	0.81	0.12
QLD	2018/19	0.80	0.12
SA	2015/16	0.53	0.10
SA	2016/17	0.51	0.10
SA	2017/18	0.44	0.09
SA	2018/19	0.35	0.07
WA	2015/16	0.70	0.06
WA	2016/17	0.70	0.05
WA	2017/18	0.69	0.02
WA	2018/19	0.69	0.02
TAS	2015/16	0.19	0.03
TAS	2016/17	0.23	0.03
TAS	2017/18	0.19	0.03
TAS	2018/19	0.16	0.02

NT	2015/16	0.65	0.09
NT	2016/17	0.64	0.09
NT	2017/18	0.63	0.07
NT	2018/19	0.57	0.05

Table 46: Emission Factors for the Consumption of Gaseous Fuels

Fuel Combusted	Energy Content	CO_2	CH_4	N_2O
Natural Gas Distributed in a Pipeline	39.3 × 10-3	51.4	0.1	0.03
Coal seam methane that is captured for combustion	37.7 × 10-3	51.4	0.2	0.03
Coal mine waste gas that is captured for combustion	37.7 × 10-3	51.9	4.6	0.3
Compressed natural gas (reverting to standard conditions)	39.3 × 10-3	51.4	0.1	0.03
Unprocessed natural gas	39.3 × 10-3	51.4	0.1	0.03
Ethane	62.9 × 10-3	56.5	0.03	0.03
Coke oven gas	18.1 × 10-3	37.0	0.03	0.05
Blast furnace gas	4.0 × 10-3	234.0	0.03	0.02
Town gas	39.0 × 10-3	60.2	0.04	0.03
Liquefied natural gas	25.3 GJ/kL	51.4	0.1	0.03
Gaseous fossil fuels other than those mentioned in the items above	39.3 × 10-3	51.4	0.1	0.03
Landfill biogas that is captured for combustion (methane only)	37.7 × 10-3	0.0	6.4	0.03
Sludge biogas that is captured for combustion (methane only)	37.7 × 10-3	0.0	6.4	0.03
A biogas that is captured for combustion, other than those mentioned in the items above	37.7 × 10-3	0.0	6.4	0.03

Table 47: Natural Gas Leakage Factors

State	UAG	CO_2	CH_4
NSW and ACT	2.2	0.8	437
VIC	3.0	0.9	435
QLD	1.7	0.8	423
WA	2.9	1.1	408
SA	4.9	0.8	437
TAS	0.2	0.9	435
NT	2.2	0.0	352

Table 48: Fuel Combustion Emissions Factors – Solid Fuels Including Certain Coal Based Products

Fuel Combusted	Energy Content	CO_2	CH_4	N_2O
Bituminous coal	27.0	90.0	0.04	0.2
Sub-bituminous coal	21.0	90.0	0.04	0.2
Anthracite	29.0	90.0	0.04	0.2
Brown coal	10.2	93.5	0.02	0.3
Coking coal	30.0	91.8	0.03	0.2
Coal briquettes	22.1	95.0	0.08	0.3
Coal coke	27.0	107	0.03	0.2
Coal tar	37.5	81.8	0.03	0.2
Solid fossil fuels other than those mentioned in the items above	22.1	95.0	0.08	0.2
Industrial materials and tyres that are derived from fossil fuels, if recycled and combusted to produce heat or electricity	26.3	81.6	0.03	0.2
Non-biomass municipal materials, if combusted to produce heat or electricity	10.5	87.1	0.8	1.0
Dry wood	16.2	0.0	0.1	1.1
Green and air dried wood	10.4	0.0	0.1	1.1
Sulphite lyes	12.4	0.0	0.08	0.5
Bagasse	9.6	0.0	0.3	1.1
Biomass, municipal and industrial materials, if combusted to produce heat or electricity	12.2	0.0	0.8	1.0

Charcoal	31.1	0.0	5.3	1.0
Primary solid biomass fuels other than those mentioned in the items above	12.2	0.0	0.8	1.0

Table 49: Fuel Combustion Emissions Factors – Liquid Fuels Including Certain Petroleum Based Products for Stationary Energy Purposes

Fuel Combusted	Energy Content	CO_2	CH_4	N_2O
Petroleum based oils (other than petroleum based oil used as fuel), eg lubricants	38.8	13.9	0.0	0.0
Petroleum based greases	38.8	3.5	0.0	0.0
Crude oil including crude oil condensates	45.3 GJ/t	69.6	0.08	0.2
Other natural gas liquids	45.3 GJ/t	61.0	0.08	0.2
Gasoline (other than for use as fuel in an aircraft)	34.2	67.4	0.2	0.2
Gasoline for use as fuel in an aircraft (avgas)	33.1	67.0	0.2	0.2
Kerosene (other than for use as fuel in an aircraft)	37.5	68.9	0.01	0.2
Kerosene for use as fuel in an aircraft (aviation turbine fuel)	36.8	69.6	0.02	0.2
Heating oil	37.3	69.5	0.03	0.2
Diesel oil	38.6	69.9	0.1	0.2
Fuel oil	39.7	73.6	0.04	0.2
Liquefied aromatic hydrocarbons	34.4	69.7	0.03	0.2
Solvents: mineral turpentine or white spirits	34.4	69.7	0.03	0.2
Liquefied petroleum gas	25.7	60.2	0.2	0.2
Naphtha	31.4	69.8	0.01	0.01
Petroleum coke	34.2 GJ/t	92.6	0.08	0.2
Refinery gas and liquids	42.9 GJ/t	54.7	0.03	0.03

Refinery coke	34.2 GJ/t	92.6	0.08	0.2
Petroleum based products other than mentioned in the items above	34.4	69.8	0.02	0.1
Biodiesel	34.6	0.0	0.08	0.2
Ethanol for use as a fuel in an internal combustion engine	23.4	0.0	0.08	0.2
Biofuels other than those mentioned in the items above	23.4	0.0	0.08	0.2

Table 50: Fuel Combustion Emissions Factors – Fuels Used for Transport Energy Purposes (Post 2004 vehicles)

Fuel Type	Energy Content	CO_2	CH_4	N_2O
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	0.5
Liquefied petroleum gas	26.2	60.2	0.5	0.3
Ethanol for use as fuel in an internal combustion engine	23.4	0	0.2	0.2

Table 51: Fuel Efficiency by Vehicle Type

Fuel Type	Petrol	Diesel
Passenger Vehicles	10.7	11.5
Motor cycles	5.8	0
Light commercial vehicles	12.8	12.3
Rigid trucks	20.9	28.7
Articulated trucks	0	55.2
Non-freight carrying trucks	14.5	21.3
Buses	20.4	29.1

Table 52: Rail Emissions Intensity Factors

Vehicle Type	Emissions Intensity
Rail	= 1678.5/16.14/1000

Table 53: Tram Energy Efficiency Factors

Vehicle Type	Energy Efficiency (MJ/p km)
Tram	0.36

Table 54: Enteric Fermentation Emissions Factors

Category	Emissions Factor (kg/head/year)
Dairy cattle	68
Non-dairy cattle	53
Sheep	8
Pigs	1.5

Table 55: Manure Management Emissions Factors

Category	Cool	Temp	Warm
Sheep/Lambs	0.19	0.28	0.37
Dairy Cattle	31	32	33
Non-Dairy Cattle	5	6	7
Pigs	20	20	20
Live Poultry	0.03	0.03	0.03

Appendix C - Industrial Subsectors Lookup Table

Table 56: Australian Bureau of Statistics Industrial Subsectors Lookup

Category	ID		Category	ID
Agriculture, Forestry and Fishing, nfd	1a		Food and Beverage Services	8c
Agriculture	1b		Transport, Postal and Warehousing, nfd	9a
Aquaculture	1c		Road Transport	9b
Forestry and Logging	1d		Rail Transport	9c
Fishing, Hunting and Trapping	1e		Water Transport	9d
Agriculture, Forestry and Fishing Support Services	1f		Air and Space Transport	9e
Mining, nfd	2a		Other Transport	9f
Coal Mining	2b		Postal and Courier Pick-up and Delivery Services	9g
Oil and Gas Extraction	2c		Transport Support Services	9h
Metal Ore Mining	2d		Warehousing and Storage Services	9i
Non-Metallic Mineral Mining and Quarrying	2e		Information Media and Telecommunications, nfd	10a
Exploration and Other Mining Support Services	2f		Publishing (except Internet and Music Publishing)	10b
Other mining	2g		Motion Picture and Sound Recording Activities	10c
Manufacturing, nfd	3a		Broadcasting (except Internet)	10d
Food Product Manufacturing	3b		Internet Publishing and Broadcasting	10e
Beverage and Tobacco Product Manufacturing	3c		Telecommunications Services	10f
Textile, Leather, Clothing and Footwear Manufacturing	3d		Internet Service Providers, Web Search Portals and Data Processing Services	10g
Wood Product Manufacturing	3e		Library and Other Information Services	10h
Pulp, Paper and Converted Paper Product Manufacturing	3f		Financial and Insurance Services, nfd	11a
Printing (including the Reproduction of Recorded Media)	3g		Finance	11b

Petroleum and Coal Product Manufacturing	3h		Insurance and Superannuation Funds	11c
Basic Chemical and Chemical Product Manufacturing	3i		Auxiliary Finance and Insurance Services	11d
Polymer Product and Rubber Product Manufacturing	3j		Rental, Hiring and Real Estate Services, nfd	12a
Non-Metallic Mineral Product Manufacturing	3k		Rental and Hiring Services (except Real Estate)	12b
Primary Metal and Metal Product Manufacturing	3l		Property Operators and Real Estate Services	12c
Fabricated Metal Product Manufacturing	3m		Professional, Scientific and Technical Services, nfd	13a
Transport Equipment Manufacturing	3n		Professional, Scientific and Technical Services (except Computer System Design and Related Services)	13b
Machinery and Equipment Manufacturing	3o		Computer System Design and Related Services	13c
Furniture and Other Manufacturing	3p		Administrative and Support Services, nfd	14a
Food, beverages and tobacco	3q		Administrative Services	14b
Electricity, Gas, Water and Waste Services, nfd	4a		Building Cleaning, Pest Control and Other Support Services	14c
Electricity Supply	4b		Public Administration and Safety, nfd	15a
Gas Supply	4c		Public Administration	15b
Water Supply, Sewerage and Drainage Services	4d		Defence	15c
Waste Collection, Treatment and Disposal Services	4e		Public Order, Safety and Regulatory Services	15d
Construction, nfd	5a		Education and Training, nfd	16a
Building Construction	5b		Preschool and School Education	16b
Heavy and Civil Engineering Construction	5c		Tertiary Education	16c
Construction Services	5d		Adult, Community and Other Education	16d
Wholesale Trade, nfd	6a		Health Care and Social Assistance, nfd	17a
Basic Material Wholesaling	6b		Hospitals	17b
Machinery and Equipment Wholesaling	6c		Medical and Other Health Care Services	17c

Motor Vehicle and Motor Vehicle Parts Wholesaling	6d		Residential Care Services	17d
Grocery, Liquor and Tobacco Product Wholesaling	6e		Social Assistance Services	17e
Other Goods Wholesaling	6f		Arts and Recreation Services, nfd	18a
Commission-Based Wholesaling	6g		Heritage Activities	18b
Retail Trade, nfd	7a		Creative and Performing Arts Activities	18c
Motor Vehicle and Motor Vehicle Parts Retailing	7b		Sports and Recreation Activities	18d
Fuel Retailing	7c		Gambling Activities	18e
Food Retailing	7d		Other Services, nfd	19a
Other Store-Based Retailing	7e		Repair and Maintenance	19b
Non-Store Retailing and Retail Commission-Based Buying and/or Selling	7f		Personal and Other Services	19c
Accommodation and Food Services, nfd	8a		Private Households Employing Staff and Undifferentiated Goods and Service-Producing Activities of Households for Own Use	19d
Accommodation	8b			

Table 57: Australian Energy Statistics Industrial Subsectors Lookup

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	

Appendix D – Temporal Scaling Method

Approach

Snapshot emissions profiles are available for both financial years and calendar years. However, most time series data sets which are used to derive emissions profiles nationally have varied temporal scaling, that is, each data set is generally available for financial years, calendar years or every four years (Census). Therefore, temporal scaling is required for time series data sets to ensure they are available for both financial years and calendar years for all reporting periods available via the Snapshot website.

Method

This method is a two-stage process. The first stage is to derive the missing time periods between non-missing time periods using the midpoint. For example, population which is provided by the Australian Bureau of Statistics is available each calendar year and the population for Nilumbik in 2019 is 65,094 and 2020 is 65,219. Therefore, the population in 2019/20 is 65,157 using the midpoint between 2019 and 2020.

The final stage is to use simple linear regression to estimate time periods both prior and beyond existing time periods if required. The first stage is important since linear regression will produce different estimates compared to the midpoint provided there are at least three time periods, and the midpoint is likely to be more accurate than linear regression for historical time periods when there is lots of data.

Simple linear regression is a linear regression model with a single explanatory variable. It finds a linear function which predicts the dependent variable (i.e. population) as a function of the independent variable (i.e. year). This method produces a constant and a coefficient for year such that the dependant variable (i.e. population) can be estimated for any year (calendar and financial years). In the regression analysis financial years i.e. 2017/18 are denoted 2017.5 to ensure they are numerical for the analysis.

References

Table 58: Basic Metrics Data References

Reference	Description	Source	Location	URL
BMS-R1	Population	Australian Bureau of Statistics		https://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
BMS-R2	DWTD Dwelling type - Total	Australian Bureau of Statistics		https://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
BMS-R3	SEIFA	Australian Bureau of Statistics		https://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
BMS-R3	Jobs in the INDP level 1 category	Australian Bureau of Statistics		https://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
BMS-R5	Jobs in the INDP level 2 category	Australian Bureau of Statistics		https://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
BMS-R6	Jobs in the OCCP level 1 category	Australian Bureau of Statistics		https://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
BMS-R7	Jobs in the INDP level 4 category	Australian Bureau of Statistics		https://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
BMS-R8	Commercial jobs and building approvals	Economic Indicators		https://content.id.com.au/state-of-the-regions-economic-indicators
BMS-R9	Local Government Area Concordances	Australian Bureau of Statistics		https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1270.0.55.003 June%202020?OpenDocument
BMS-R10	Postcode Concordances	Australian Bureau of Statistics		https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1270.0.55.003 June%202020?OpenDocument
BMS-R11	SA4 Concordances	Australian Bureau of Statistics		https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1270.0.55.003 June%202020?OpenDocument

BMS-12	IBRA7 Concordances	Australian Department of Environment and Energy		http://www.environment.gov.au/land/nrs/science/ibra/ibra7-codes

Table 59: Stationary Energy Data References

Reference	Description	Source	Location	URL
SE-R1	QLD electricity municipality activity data by sector	Energex		https://www.energex.com.au/about-us/company-information/our-network/data-to-share/energy-usage-data-to-share
SE-R2	NSW electricity municipality activity data by sector	Ausgrid		https://www.ausgrid.com.au/Industry/Our-Research/Data-to-share/Average-electricity-use
SE-R3	State level stationary energy activity data by sector	Australian Energy Statistics	Table F	https://www.energy.gov.au/publications/australian-energy-update-2022
SE-R4	Safeguard Mechanism	Safeguard Mechanism		https://www.cleanenergyregulator.gov.au/NGER/The-safeguard-mechanism/safeguard-data/safeguard-facility-reported-emissions
SE-R5	National Pollutants Inventory	National Pollutants Inventory		https://www.dcceew.gov.au/environment/protection/npi
SE-R6	NSW residential gas municipality activity data	Jemena		https://data.peclet.com.au/explore/dataset/jemena-average-gas-consumption-lga-level/table/
SE-R7	Natural Gas Availability	Australian Gas Networks		https://www.australiangasnetworks.com.au/
SE-R8	Tas Gas Pipeline Locator	Tas Gas Networks		
SE-R9	WA Gas Pipeline Network Coverage Maps	ATCO		

Ironbark

Table 60: Transport Data References

Reference	Description	Source	Location	URL
TRA-R1	Register of motor vehicles by LGA and vehicle type	Australian Bureau of Statistics		https://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
TRA-R2	Register of motor vehicles by LGA and fuel type	Australian Bureau of Statistics		https://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
TRA-R3	Total fuel sales by fuel type	Australian Petroleum Statistics, Department of Climate Change, Energy, the Environment and Water		https://www.energy.gov.au/government-priorities/energy-data/australian-petroleum-statistics
TRA-R4	NSW Vehicle registrations by vehicle type and fuel type	Transport for NSW		https://roads-waterways.transport.nsw.gov.au/about/corporate-publications/statistics/registrationandlicensing/tables/table114_2021q1.html
TRA-R5	Activity data (total distance) by transport mode and boundary type	Google EIE		https://insights.sustainability.google/
TRA-R6	Australian Domestic Airline Activity – Time Series	BITRE		https://www.bitre.gov.au/publications/ongoing/domestic_airline_activity-time_series
TRA-R7	Airport Traffic Data	BITRE		https://www.bitre.gov.au/publications/ongoing/airport_traffic_data
TRA-R8	ICAO Carbon Emissions Calculator	ICAO		https://www.icao.int/environmental-protection/Carbonoffset/Pages/default.aspx

Table 61: Waste Data References

Reference	Description	Source	Location	URL
WST-R1	Solid Waste by Sector	Randell Consulting		https://www.dcceew.gov.au/environment/protection/waste/national-waste-reports/2020

Table 62: Agriculture Data References

Reference	Description	Source	Location	URL
AGR-R1	Agriculture commodities by LGA	Australian Bureau of Statistics		https://www.abs.gov.au/statistics/industry/agriculture/agricultural-commodities-australia/latest-release
AGR-R2	Agriculture commodities by ASGS regions	Australian Bureau of Statistics		https://www.abs.gov.au/statistics/industry/agriculture/agricultural-commodities-australia/latest-release
AGR-R3	Agriculture commodities by state	Australian Bureau of Statistics		https://www.abs.gov.au/statistics/industry/agriculture/agricultural-commodities-australia/latest-release

Table 63: Land Use Data References

Reference	Description	Source	Location	URL
LU-R1	Primary Conversion Area by kha	Department of Environment and Energy		https://www.dcceew.gov.au/
LU-R2	Re-clearing area by kha	Department of Environment and Energy		https://www.dcceew.gov.au/
LU-R3	Forest Regrowing by kha	Department of Environment and Energy		https://www.dcceew.gov.au/

Table 64: Australia's National Greenhouse Accounts Data References

Reference	Description	Source	Location	URL
NGA-R1	Australia's National Greenhouse Accounts	Australia's National Greenhouse Accounts		https://ageis.climatechange.gov.au/

Table 65: Emissions Factors References

Reference	Description	Source	Location	URL
Table 45	Grid Electricity Scope Factors	National Greenhouse Account Factors	Table 46	https://www.dcceew.gov.au/sites/default/files/documents/national-greenhouse-accounts-factors-2021.pdf
Table 46	Emissions Factors for the Consumption of Gaseous Fuels	National Greenhouse Account Factors	Table 2	https://www.dcceew.gov.au/sites/default/files/documents/national-greenhouse-accounts-factors-2021.pdf
Table 47	Natural Gas Leakage Factors	National Greenhouse Account Factors	Table 21	https://www.dcceew.gov.au/sites/default/files/documents/national-greenhouse-accounts-factors-2021.pdf
Table 48	Fuel Combustion Emissions Factors – Solid Fuels Including Certain Coal Based Products	National Greenhouse Account Factors	Table 1	https://www.dcceew.gov.au/sites/default/files/documents/national-greenhouse-accounts-factors-2021.pdf
Table 49	Fuel Combustion Emissions Factors – Liquid Fuels Including Certain Petroleum Based Products for Stationary Energy Purposes	National Greenhouse Account Factors	Table 3	https://www.dcceew.gov.au/sites/default/files/documents/national-greenhouse-accounts-factors-2021.pdf
Table 50	Fuel Combustion Emissions Factors – Fuels Used for Transport Energy Purposes (Post 2004 vehicles)	National Greenhouse Account Factors	Table 4	https://www.dcceew.gov.au/sites/default/files/documents/national-greenhouse-accounts-factors-2021.pdf
Table 51	Fuel efficiency by vehicle type	Australian Bureau of Statistics	Table 6	https://www.abs.gov.au/statistics/industry/tourism-and-transport/survey-motor-vehicle-use-australia/latest-release
Table 52	Rail Emissions Intensity Factors	BITRE Trainline 7		https://www.bitre.gov.au/publications/2019/trainline-7
Table 53	Energy efficiency by mode in high income cities	Curtin University	Table 2.7	https://espace.curtin.edu.au/bitstream/handle/20.500.11937/37681/160925_160925.pdf?sequence=2
Table 54	Enteric Fermentation Emissions Factors	IPCC	Table 4-3 and Table 4-4	https://www.ipcc-nggip.iges.or.jp/public/gl/invs6c.html
Table 55	Manure Management Emissions Factors	IPCC	Table 4-5 and Table 4-6	https://www.ipcc-nggip.iges.or.jp/public/gl/invs6c.html

Figure 3	Annual Carbon Losses in Biomass due to Disturbances	IPCC		https://www.ipcc-nggip.iges.or.jp/public/gl/invs6c.html
Figure 4	Above-Ground Biomass in Forests	IPCC		https://www.ipcc-nggip.iges.or.jp/public/gl/invs6c.html
Figure 5	Ratio of Below-Ground Biomass to Above-Ground Biomass	IPCC		https://www.ipcc-nggip.iges.or.jp/public/gl/invs6c.html

Glossary

Term	Definition
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences (previously Australian Bureau of Agricultural and Resource Economics or ABARE)
ABS	Australian Bureau of Statistics
Activity Data	Activity data is a quantitative measure of a level of activity that results in GHG emissions taking place during a given period of time (e.g., volume of gas used, kilometres driven, tonnes of solid waste sent to landfill, etc.)
AEC	Australian Energy Council
AFOLU	Agriculture, Forestry, and Other Land Use
BASIC	Reporting level outlined in the GPC. The BASIC level covers scope 1 and scope 2 emissions from stationary energy and transportation, as well as scope 1 and scope 3 emissions from waste.
BASIC+	Reporting level outlined in the GPC. BASIC+ involves additional data collection and calculation processes, requiring emissions from IPPU, emissions and removals from AFOLU, scope 3 emissions from stationary energy, and emissions from transboundary transportation.
C	Data relating to these emissions is confidential (GPC Notation Key)
C&D	Construction and demolition
C&I	Commercial and industrial
C40	C40 Cities Climate Leadership Group
CCA	Climate Change Authority
CCP	Cities for Climate Protection
cCR	Carbonn Climate Register
CH_4	Methane
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent. The universal unit of measurement to indicate the global warming potential (GWP) of each GHG, expressed in terms of the GWP of one unit of carbon dioxide. It is used to evaluate the climate impact of releasing (or avoiding releasing) different GHGs on a common basis.
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DNSP	Distribution Network Service Provider (Electricity Network)
DNSP	Distribution Network Service Provider (Electricity Network)

Emissions Coefficient Factors (Emissions Factors)	An emissions factor is a measure of the mass of GHG emissions relative to a unit of activity.
Emissions Factor	An emissions factor is a measure of the mass of GHG emissions relative to a unit of activity.
ENA	Electricity Networks Australia
ERF	Emissions Reduction Fund
GHG Protocol	The Greenhouse Gas Protocol, developed by World Resources Institute and World Business Council on Sustainable Development, sets the global standard for how to measure, manage, and report GHG emissions.
Global Covenant of Mayors	Global Covenant of Mayors for Climate & Energy is a coalition of city leaders addressing climate change by pledging to reduce their greenhouse gas emissions, tracking their progress and preparing for the impacts of climate change. It was formed through a merger of the Compact of Mayors and the Covenant of Mayors.
Global Covenant of Mayors for Climate and Energy (GCom)	The Global Covenant of Mayors for Climate & Energy was established in 2016 by bringing formally together the Compact of Mayors and the European Union's Covenant of Mayors. It is a global coalition of city leaders addressing climate change by pledging to cut greenhouse gas emissions and prepare for the future impacts of climate change. Global Covenant of Mayors for Climate & Energy is a coalition of city leaders addressing climate change by pledging to reduce their greenhouse gas emissions, tracking their progress and preparing for the impacts of climate change. It was formed through a merger of the Compact of Mayors and the Covenant of Mayors.
GPC	Global Protocol for Community-Scale Greenhouse Gas Emission Inventories
Greenhouse Gas (GHG) Emissions	Greenhouse gas emissions. Greenhouse gases are the atmospheric gases responsible for causing global warming and climate change. The Kyoto Protocol lists six greenhouse gases – carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur-hexafluoride (SF6) – with the addition of nitrogen trifluoride (NF3) from the beginning of the protocol's second commitment period.
Gross Regional Product (GRP)	Gross regional product (GRP) is a monetary measure of the market value of all final goods and services produced in a region or subdivision of a country in a period (quarterly or yearly) of time. A metropolitan area's GRP (gross metropolitan product, GMP), is one of several measures of the size of its economy.
GRP	Gross Regional Product
GSP	Gross State Product
Gt	Gigatonne
GWP	Global Warming Potential. The Global Warming Potential was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of one tonne of a gas will absorb over a given period of time, relative to the emissions of one tonne of carbon dioxide
ICLEI	International Council for Local Government Initiatives
IE	Emissions have been included elsewhere (GPC Notation Key)
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use

kt	Kilotonne
LGA	Local Government Area
MCF	Methane Correction Factor
MERL	Monitoring, evaluation, review and learning
Mt	Megatonne
N_2O	Nitrous oxide
NE	Emissions were not estimated (GPC Notation Key)
NO	No emissions occurring (GPC Notation Key)
Regression	A regression is an estimate of the line that describes the relationship between two variables. The equation of the regression line is used to predict (or estimate) the value of the response variable from a given value of the explanatory variable. For example: connecting the population of a municipality to the emissions generated to enable the estimation of emissions for future years or other municipalities.
SEIFA	Socio-Economic Indexes for Areas.
Temporal Scaling	This allows us to use data from previous years to estimate the emissions for years where actual data is not available. For example: We have data for gas consumption from 2019 and want to estimate the emissions for 2022. We can use changes in other variables such as population or household growth which we have 2022 data for to estimate the changes in gas consumption.
WRI	World Resources Institute