Ironbark Sustainability

Snapshot Climate Methodology 2023

Prepared for the Australian community.

Version	Author	Date	Description of changes
V0a	Richard Ryall	20/11/2023	Draft
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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)

Snapshot Climate has been developed by Ironbark Sustainability to give councils and communities free access to high quality community emissions data to support effective climate action.

Snapshot Climate is the first national tool with data for every region in Australia. We use the same approach nationwide 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 Climate 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 to achieve optimal emissions reduction. For this reason, the methodology, including data sources, is freely available in this document.

1.1 Verification

Snapshot Climate has been developed with input from Australia's leading experts and is 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 Climate data, methodology and calculations have been independently verified as aligned with the Global Protocol for Community-Scale Greenhouse Gas Inventories (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 considered to be aligned with the GPC and 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 Snapshot Climate.

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 (GCOM) and the Carbon Disclosure Project (CDP).
- They are consistent for municipalities across Australia (unless superior data is available for a reasonable subset of municipalities), 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 (though only for the categories that are within the scope of these profiles).
- The methods only use publicly available data, ensuring that others can replicate the outcomes of the approach. This improves transparency and verification options.

2.1 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.

2.2 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 (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 Agriculture, Forestry and Other Land Use (AFOLU), scope 3 emissions from stationary energy, and emissions from transboundary transportation.

Global Protocol for Community-Scale Greenhouse Gas Inventories v1.1 (p12)

2.3 Navigation

2.3.1 Methods by source and sector

Data sources include stationary energy (electricity and gas), waste, agriculture, transport, Industrial Processes and Product Use (IPPU) and fugitive emissions.

The data in Snapshot Climate is grouped first by emissions source and then by sector (e.g. residential, commercial and industrial). Each source and sector combination has an accompanying methodology.

The methodology sections in this document are ordered by source and described in laypersons terms.

2.3.2 Methods by state and year

The availability of data can vary between states and reporting years. To ensure best practice across all profiles it is therefore sometimes necessary to use different data sets and methods.

2.3.3 Data sources

All data sources used in the Snapshot methodology are provided in Section 11 of the Appendix.

2.4 Improving methods over time

The value of community emissions profiles in climate action planning is becoming increasingly apparent. This leads to significant improvements in the availability of activity data at the community scale (such as residential electricity consumption or kilometers travelled by bus) which contribute to improve the quality of the emissions profiles developed.

Snapshot Climate aims to represent best practice in the development of community emissions profiles. 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, but this has several implications, including changes to historical profiles and differences in methodology between municipalities.

2.4.1 Changes to historical profiles

After we adopt a new and improved data source or methodology, we then update historical emissions profiles with the same data and approach (if historical new and improved data is available). This enables comparison between different years, ensures that all profiles on Snapshot Climate are consistent in their methods, and that all profiles represent best practice.

For this reason, you may find that updated Snapshot Climate profiles differ from versions downloaded previously. 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 on the Snapshot Climate website.

2.4.2 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 there are limitations when comparing actual activity data with modelled activity data at the municipality level. For example, a municipality with real activity data can use this data to monitor and evaluate the impact of actions and interventions whereas a municipality with modelled activity data can't use this data for the same purpose.

2.4.3 Independently developed profiles

Some councils or territories (such as the Australian Capital Territory) have developed their own community emissions profiles independently, which may differ from their Snapshot Climate profile. Where the publication of different profiles 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 page, and you will need to contact the council directly to get more information on the method employed.

2.5 Citation

We encourage you to reference the Snapshot 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. (2023, November). Snapshot Climate Methodology 2023. https://snapshotclimate.com.au/resources/

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

2.6 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.

2.7 Disclaimer

While every effort has been made to use data from reputable sources and a thorough quality assurance process has been undertaken, neither Snapshot Climate users nor Ironbark Sustainability are responsible for data inaccuracies by third parties.

3. Emissions sources

3.1 Stationary energy - Electricity

Stationary energy is the combustion of fuel for energy purposes in all uses other than transport. It includes electricity generation, oil refineries, and direct combustion of industrial heat. Here, we focus on the electricity generation component, which makes up most stationary energy emissions. This largely refers to electricity generated for buildings but may also include streetlights and electricity from diesel generators. This emissions source includes electricity consumed by the residential, commercial, and industrial sectors.

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

3.1.1 Residential electricity

Residential electricity is modelled using a combination of municipality consumption data from DNSPs and state level consumption data which is provided by Australian Energy Statistics. DNSP data is measured in kWh and is a mix of monthly and annual consumption data for different providers. DNSP data is available for several NSW, VIC and QLD municipalities and is always used when available. When DNSP data is unavailable, electricity consumption is estimated using a regression model based on the available DNSP data and several residential characteristics including population, household type and a socio-economic index (SEIFA). An additional normalisation process is applied to the modelled DNSP data to ensure the actual DNSP data and modelled DNSP data sum to the state level consumption data for the residential sector for each state.

Appropriate emissions factors and conversion factors are applied to convert the consumption data into emissions.

Since residential electricity activity data is highly correlated with population and households the modelled data is very accurate.

3.1.2 Commercial and industrial electricity

Although business DNSP consumption data is available for several municipalities in NSW, VIC and QLD, it doesn't distinguish between commercial and industrial sectors and also omits large organisations due to privacy concerns. Therefore, this data is excluded from Snapshot primarily because it is not complete.

Instead, this data is sourced from the Australian Energy Statistics (AES), which aggregates electricity consumption data at the state level for the commercial sector but provides a more granular breakdown for industrial subsectors. These categories and level of granularity align reasonably well with the Australian Bureau of Statistics (ABS) categories. The most granular category provided by the ABS is the Australian and New Zealand Standard Industrial Classification (ANZSIC), which has over 500 unique categories. The ANZSIC categories are more granular than the data provided by AES therefore the AES state level consumption data is apportioned to individual ANZSIC categories based on proportion of jobs of each ANZSIC category within an AES category for each municipality relative to the state. It is important to note the jobs data is based on the location of the job not the principal place of resident of the

worker so is a very good proxy for the relative size of operations within each sector and municipality.

The ABS jobs data is broken down by Level 4 Industry of Employment (INDP4) (i.e. ANZSIC) and Level 1 Occupation Data (OCCP1) (e.g. professionals, technical and trade workers). The commercial jobs for each ANZSIC category contain all OCCP1 categories, whereas the industrial jobs are limited to technical employees (namely technicians and trades workers, machinery operators and drivers and labourers) for the OCCP1 categories. For example, for the mining sector clerical and administrative workers are excluded since they don't directly have much impact on emissions. Emissions factors are then applied which creates initial modelled emissions data for each municipality for each ANZSIC category.

Key emitters data (defined in Section 4) have a corresponding ANZSIC category which enables the key emitters data to be merged with the state level modelled ANZSIC electricity consumption data described above. This integration process uses the key emitters data when available for each ANZSIC category and the remaining emissions are distributed based on the initial modelled emissions using jobs data. This ensures all emissions data for all ANZSIC categories still sum to the state totals for each sector. Since the emissions intensity for each commercial sector is different, an additional coefficient is applied to the jobs data allocation process to account for this. This coefficient is based on emissions intensity data (e.g. in tonnes CO2-e/kWh), for each source and sector provided by CSIRO.

3.2 Stationary energy - Gas

Another form of stationary energy that Snapshot Climate reports is gas. Emissions sources from gas largely come from buildings, through space and water heating, which also includes gas boilers, for example, at aquatic centres. Gas is consumed by the residential, commercial and industrial sectors. Unlike electricity, not all municipalities have gas connections. Therefore, research has been undertaken to determine which municipalities have a gas connection and of these, what proportion of buildings within the municipality, have gas connections. Please note LPG gas has been excluded due to limited data availability.

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

3.2.1 Residential Gas

Residential gas is modelled using a combination of DNSP municipality consumption data and state level consumption data which is provided by the AES. DNSP data is measured in GJ and is solely annual consumption data from Jemena. DNSP data is available for several NSW municipalities and is always used when available. When DNSP data is unavailable, gas emissions are estimated using a regression model based on the available DNSP data and several residential characteristics including population, household types and socio-economic indexes (SEIFA). An additional normalisation process is applied to the modelled DNSP data to ensure the actual DNSP data and modelled DNSP data sum to the state level consumption data. Additional constraints are applied to account for municipalities without gas connections to ensure no gas emissions are attributed to these municipalities whilst ensuring the modelled residential gas emissions for each municipality still add to the state total.

3.2.2 Commercial and industrial gas

The same allocation process is applied to commercial and industrial gas as it is for commercial and industrial electricity, as per Section 3.2. Additional constraints are applied to account for municipalities without gas connections.

3.3 Industrial processes and product use (IPPU)

The industrial processes and product use (IPPU) sector covers greenhouse gas emissions resulting from various industrial activities which are not directly the result of energy consumed during the process. This includes emissions from industrial processes that physically or chemically transform materials (for example emissions associated with concrete production), and the use of man-made greenhouse gases in products – namely refrigerants.

3.4 Product use – Refrigerants

This method takes data from Australia's National Greenhouse Accounts (ANGA, previously referred to as the Australian Greenhouse Emissions Information System, AGEIS), and is integrated alongside relevant scaling factors to derive product use emissions for refrigeration and air conditioning. This represents Scope 1 emissions for refrigerant product use and covers residential refrigeration, commercial refrigeration, industrial refrigeration, residential air conditioning, commercial air conditioning and transport air conditioning.

Table 1 shows the AGEIS categories for refrigerants and the corresponding Snapshot emissions categories and scaling factors. For each subsector of emissions, a specific scaling factor has been established, to scale the state emissions to the municipality level.

Table 1: Product User Categories

AGEIS Category	Snapshot Refrigerant Category	Scaling Factor
Stand-alone Commercial Applications	Commercial refrigeration	Commercial jobs
Industrial refrigeration including food processing and cold storage	Industrial refrigeration	Transport jobs
Medium and large commercial refrigeration	Industrial refrigeration	Food processing jobs
Domestic refrigeration	Residential refrigeration	Households
Mobile air-conditioning	Transport air conditioning	Passenger vehicles
Domestic stationary air conditioning	Residential air conditioning	Households
Commercial air conditioning	Commercial air conditioning	Commercial jobs
Transport refrigeration	Industrial refrigeration	Heavy vehicles

3.5 Industrial processes

Industrial processes comprise of Scope 1 emissions from industrial processes within a given boundary and include cement manufacturing, basic inorganic chemical manufacturing and primary metal and metal product manufacturing. There are a range of large emitting facilities across Australia, which in some instances have industrial processes that can be in 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. For example, BlueScope Steel is one of Australia's biggest emitters which has its major operations in Wollongong. Incorporating the key emitters data resulted in a significant increase in Wollongong's emissions and a reduction in other municipality emissions which had jobs within the same industry namely iron smelting and steel manufacturing. This suggests while the jobs method provides a good approximation in the commercial sector it is likely to underestimate certain industrial subsectors.

Industrial processes are modelled using a hybrid approach which incorporates key emitters (defined in Section 10) and national industrial processes emissions data provided by Australia's Nation Greenhouse Accounts which is then apportioned to municipalities based on relevant scaling factors using jobs data. This ensures industrial processes emissions are fully accounted for whilst also ensuring location based key emitters are incorporated.

National level industrial processes emissions data are available for 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, then it is included in Snapshot otherwise it is excluded.

Therefore, industrial processes are limited to the mineral industry, chemical industry and metal industry sectors. For reference, the excluded sectors include non-energy products and electronics industry.

The mineral industry is constrained to cement production and lime production, and the chemical industry is constrained to ammonia production and nitric acid production. These constraints are required since these data are scaled to the municipality level via jobs allocation and the jobs categories need to align well with industrial processes emissions categories. Table 2 shows the AGEIS categories for industrial processes and the corresponding scaling factors based on jobs allocation.

Table 2: Industrial Process Categories

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	N/A	Primary Metal and Metal Product Manufacturing Jobs

The key emitters data (defined in Section 4) can be merged with the national industrial processes emissions data since the jobs data provided by the ABS has numerous levels in the category hierarchy, with ANZSIC being the most granular. This integration process uses the key emitters data when available for each ANZSIC category and the remaining emissions are distributed based on the base emissions using jobs data. This ensures all emissions data for all ANZSIC categories still sum to the national totals for each sector.

3.6 Fugitive

Fugitive emissions are the gases unintentionally released during the extraction, processing, storage, transport, and discharge of fossil fuels. Fugitive emissions from coal mining, and oil and gas production account for about 8% of Australia's greenhouse gas emissions.

Australia's National Greenhouse Accounts provide fugitive emissions data for coal mining and oil and natural gas. Although some state level data and more granular data exists, this is typically not available for the majority of states and subsectors due to privacy reasons as it will likely identify certain organisations. Therefore, this data is limited to national fugitive emissions for coal mining and oil and natural gas since it is complete.

Fugitive emissions are all scope 1 emissions.

3.6.1 Coal mining

Nationally reported fugitive emissions from coal mining are first apportioned to municipalities, via jobs allocation. This data is then merged with the key emitters data (defined in Section 10) based on the ANZSIC category, Coal Mining. This integration process uses the key emitters data when available and the remaining emissions are distributed based on jobs data. This ensures emissions data for the ANZSIC Coal Mining category still sum to the national totals for coal mining.

3.6.2 Oil and gas

Fugitive emissions from oil and gas extraction are broken down by ANZSIC category and then apportioned to municipalities via jobs allocation. This data is then merged with key emitters data (defined in Section 10) based on the various oil and gas ANZSIC categories. This integration process uses the key emitters data when available and the remaining emissions are distributed based on jobs data. This ensures all emissions data for all ANZSIC categories still sum to the national totals for each sector.

3.7 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.

3.7.1 Environmental Insights Explorer (EIE) data

The Google Environmental Insights Explorer (EIE) is an online tool that provides transport data and insights for regions globally. This data includes municipality level transport activity data which can be converted to estimated emissions by applying a series of functions. The activity data represents kilometres travelled for trips that are wholly within the municipal boundary – those that begin and end within the municipality (Scope 1), and trips that begin or end within

the municipality boundary, but not both (Scope 3). This activity data is highly aggregated anonymized data generated from mobile phones.

EIE data is only available for municipalities which meet certain privacy thresholds including, but not limited to, having a population more than 25,000. EIE data is currently available for 169 municipalities nationally with this figure being relatively stable from one year to the next.

EIE data includes total distance by boundary (inbound, outbound and in-boundary), and by transport mode including automobiles, motorcycles, rail, tram, bus, walking and cycling. Inbound and outbound data is multiplied by 50% for completeness and to avoid double counting. Since there are no emissions associated with walking or cycling these categories are excluded in future analysis.

3.7.2 On road transport

This section uses the EIE data and is limited to automobiles, motorcycles and buses.

The EIE data does not contain a breakdown by fuel type, and does not differentiate between passenger vehicles and light commercial vehicles. We estimate fuel type breakdown by integrating vehicle type by fuel type data for each municipality from the ABS. The proportion of passenger vehicles and light commercial vehicles is based on Australia's National Greenhouse Accounts which provides emissions data by vehicle type (i.e. cars, light commercial vehicles, buses and motorcycles etc.) for each state.

Emissions are then derived by integrating fuel efficiency factors, energy content factors and emissions factors.

For the remaining municipalities without EIE data, emissions are estimated by using a separate regression model for each vehicle type, based on a variety of characteristics including land area, population and jobs. Scope 1 emissions (within municipality) are modelled based on emissions per vehicle since the main determinant of these emissions is the number of vehicles within the municipality. Scope 3 emissions (inter municipality) are based on total emissions since this includes people coming from outside the municipality and thus the vehicles within the municipality are largely irrelevant. This provides an estimate for passenger vehicles, light commercial vehicles, motorcycles and buses.

As with EIE data, factors for fuel efficiency factors, energy content and emissions are applied to derive modelled emissions.

EIE data is always used when it is available and models based on EIE data are used when it is unavailable. The modelled EIE data is then normalised against Australia's National Greenhouse Account emissions for each vehicle type after accounting for the EIE emissions to ensure the sum of the EIE emissions and non-EIE modelled emissions sum to the state total for each vehicle type.

3.7.3 Rail

This section uses EIE data which is limited to passenger rail, so excludes rail freight.

The EIE activity data for rail is integrated with conversion factors to convert passenger kilometres (per person) to total rail kilometres (per train) to and emissions intensity factors to derive municipality level emissions.

It is important to note that there are no modelled rail emissions for municipalities without EIE data, since not every municipality has rail stations. Furthermore, although Australia's National

Greenhouse Accounts provides rail emissions it doesn't distinguish between passenger rail and freight rail. Therefore, unlike the on road section, if non EIE rail was modelled and limited to municipalities with rail stations there would be no way to ensure EIE and non EIE rail added to the state total based on Asutralia's National Greenhouse Accounts.

3.7.4 Tram

This section uses the EIE data and is limited to trams. The EIE activity data for trams is integrated with the emissions intensity and conversion factors to derive the municipality level emissions.

It is important to note that there are no modelled tram emissions for municipalities without EIE data, since not every municipality has tram stations. Furthermore, trams are mostly for inner city municipalities in densely populated areas where EIE is likely to be available.

3.7.5 On Road Freight

On road freight incorporates both commercial and industrial freight and excludes light commercial vehicles. On road freight emissions data is available at the state level via Australia's National Greenhouse Accounts. This data can be apportioned to municipalities based on vehicle registrations of medium and heavy vehicles. To integrate key emitters data (defined in Section 10) on road freight needs to be broken down to ANZSIC categories. This is done firstly by using the fuel consumption data by sector in the AES, and then further breaking it down to ANZSIC level granularity using jobs data.

3.7.6 Aviation

Aviation transport emissions are modelled by integrating aviation data between the top routes in Australia and a larger number of regional airports. Monthly aviation data available for the top routes and 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.

An additional 51 regional airports are included by integrating a separate data set, for 92 airports in total. Six regional airports are excluded since they are not part of any Australian municipality as they lie outside the mainland boundary. Data for these regional airports are also monthly but are limited to the total number of trips per airport. The destinations of regional airports were manually extracted from Wikipedia.

A robust method is used to approximate the aircraft fuel burn for each journey using a 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 International Civil Aviation Organisation (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.

Emissions factors and energy content factors are then integrated to estimate the emissions for each airport. A lookup table is also manually created so the emissions for each airport can be allocated to a specific municipality.

It is important to note that aviation emissions are allocated solely to municipalities that have airports and are not based on the location of the residents that use the airport. Therefore, certain municipalities specifically in Australia's major capital cities with airports will have a large volume of aviation emissions.

3.8 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. Some key emitters data is available, but this has been excluded since the methodology for waste would then move away from GPC standards. If you are interested in detailed waste data for key emitters, please contact Ironbark Sustainability. Emissions from waste include Scope 1 emissions from waste sources (excluding emissions from imported waste) and Scope 3 emissions from waste generated within the boundary and exported for treatment.

3.8.1 Solid waste

This method takes data from the National Waste Report developed by Blue Environmental on behalf of the Commonwealth Government, which breaks down solid waste generation by sector and state. This is integrated with Australia's National Greenhouse Accounts solid waste emissions data and alongside relevant scaling factors, is used to derive solid waste emissions by sector at the municipality level. Solid waste sectors include residential, commercial and industrial, and construction and demolition. Table 3 shows the scaling factor for each sector.

Table 3: Solid Waste Categories

Sector	Scaling Factor
Residential	Population
Commercial and Industrial	Jobs
Construction and Demolition	Building Approvals

3.8.2 Wastewater

This method takes data from Australia's National Greenhouse Accounts and is integrated alongside relevant scaling factors to derive wastewater emissions by sector at the municipality level. Wastewater sectors include residential and industrial. Table 4 shows the scaling factor for each sector.

Table 4: Wastewater Categories

Sector	Scaling Factor
Residential	Population
Industrial	Jobs

3.9 Agriculture, forestry and other land use

3.9.1 Agriculture

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 in Snapshot Climate The determination has been to include a source if it accounts for 5% or more of total agricultural emissions. Based on this cut-off, the sectors included have been limited to enteric fermentation, manure management and agriculture soils. For reference, the excluded sectors include rice cultivation, prescribed burning, field burning, liming, urea application and application of other carbon-containing fertilisers.

This method uses the latest agriculture commodities activity data by local government area which became available in the second half of 2022. However, this data is not available for previous years and is no longer published annually. Temporal scaling is applied for previous years. Subsequent years are 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. Constraints are placed for the temporal scaling ratios due to large variances in some situations.

This method incorporates three different sectors of emissions: enteric fermentation, manure management, and agriculture soils. Enteric fermentation includes emissions from dairy cattle, beef cattle, sheep and pigs. Manure management includes emissions from dairy cattle, beef cattle, sheep, pigs and live poultry. Agriculture soils includes emissions from sugar cane, cotton, other vegetables and other crops. Emissions factors for each emissions type and sector are then applied.

The next stage is to merge the key emitters data (defined in Section 10) specific to the agriculture sector. This integration process uses the key emitters data when available and the remaining emissions are distributed based on the base emissions based on the jobs data. This ensures all emissions data for all ANZSIC categories still sum to the national totals for each sector.

3.9.2 Land clearing

Land use changes are not recorded at the municipality level by the federal government. Instead, these are collated by Bioregion (IBRA7). This method uses activity data collected according to the bioregions defined in the Interim Biogeographic Regionalisation of Australia (IBRA7). These are allocated to the municipality by intersecting Local Government Area (LGA) boundaries and IBRA7 region boundaries.

It is important to note that land use is excluded from the Snapshot chart and total emissions since it can have negative emissions associated with it (i.e. positive for the community) which can’t be displayed in a donut chart.

4. Key emitters

4.1 Introduction

Further to the development of the Snapshot Climate tool, Ironbark Sustainability can now determine key greenhouse gas emitting entities. This is derived from specific emissions data for which we can access and/or model data based on certain metrics (i.e. employees). These identified key emitters are generally the largest emitting entities, as they have greater requirements to disclose emissions data. Entities, organisations, or companies that publish their emissions publicly, typically do so at the organisation level rather than at the individual facility level. Furthermore, the emissions are not typically broken down by different emissions sources. Therefore, in order to be integrated into Snapshot, the breakdown by emissions sources is required.

Since each emissions source described in the previous seven sections integrates key emitters data a separate section was defined to clarify this method which is applicable to all emissions sources defined earlier. Furthermore, estimating the breakdown of emissions by source for key emitters requires the existing Snapshot methods so it was decided this section should be included after all the previous emissions sources methods sections.

Please contact Ironbark Sustainability (hello@snapshot.com.au) to enquire about emissions data for key emitters in your region of interest.

4.2 Data and methods

The key emitters data used in the Snapshot methodology incorporates a diverse mix or organisations. Based on the various data sources for these organisations, modelled emissions estimates come with varying levels of confidence in their accuracy. Table 5 shows the various data sets used and the corresponding confidence and methods.

Table 5: Key Emitters Data

Data	Metric	Confidence
Safeguard Mechanism	Facility level emissions	High
NGERS	Organisation level emissions	Medium
NPI	Employees	Medium/Low
Hospitals	Beds	Medium
Aged Care	Beds	Medium
Schools	Students	Medium
Open Street Maps	Land Area	Low

To integrate key emitters data into Snapshot, there are three important prerequisites: the location of the key emitters (i.e. a specific facility within a municipality); the source of emissions (i.e. electricity, gas etc.); and the corresponding ANZSIC category of the

organisation. Key emitters data generally needs to be broken down by facility and emissions source which requires modelling based on certain assumptions outlined below.

The existing Snapshot Climate tool excluding key emitters data is used to estimate the breakdown of emissions for each emissions source and for each ANZSIC category. For example, for the ANZSIC category Coal Mining, we can aggregate all the emissions across each emissions source to determine the estimated proportion of electricity, gas, fugitive and transport emissions for coal mining organisations.

It is important to note that only organisations from Safeguard, NGERS and NPI are likely to change the distribution of emissions from many municipalities to one municipality since these organisations are generally the largest emitting organisations. For example, including emissions data from Bluescope Steel results in a significant increase in emissions in Wollongong and conversely this results in a decrease in emissions for all other municipalities in the same sector namely iron smelting and steel manufacturing. Similarly, data from specific organisations in hospitals, aged care, schools and open street maps are likely to be smaller commercial organisations and are not likely to dramatically change the emissions footprint in other municipalities within the same subsector.

4.2.1 Safeguard mechanism

The Safeguard Mechanism is a publicly available data set which applies to facilities that emit more than 100,000 tCO2-e of covered emissions in a financial year (the Safeguard threshold). This extends to businesses across a broad range of industry sectors, including electricity generation, mining, oil and gas extraction, manufacturing, transport, and waste.

This data set identifies the reporting organisations and their corresponding total emissions, however the location of these facilities is not included. To attribute facilities within specific municipalities, this data set is then merged with the National Pollutants Inventory (NPI) which provides the geospatial coordinates.

If this data is available for a facility, then it is always utilised.

4.2.2 NGERS

Each year, Australian corporations that hit certain thresholds must report their emissions and energy information under the National Greenhouse and Energy Reporting Scheme (NGERS).

Unlike Safeguard data, which is facility level data that corresponds to a certain municipality, the NGERS data is organisation level data which could correspond to multiple facilities nationwide. Also, this data is typically a parent organisation which may have multiple trading facilities or franchises (i.e. Big W, Woolworths etc.). Therefore, this data can only be integrated into Snapshot Climate if it can be broken down into specific facilities.

This data has been manually matched against the NPI registry and NPI employees have been used for the allocation process if there are multiple facilities. This data has only been used for a small number of organisations due to the complexity of allocating to individual municipalities. If employee numbers are known, we can use ANZSIC categories and jobs data to allocate emissions to specific facilities according to the Snapshot Climate methodology.

This data is only used for facilities when safeguard data is unavailable.

4.2.3 NPI

The National Pollutants Inventory (NPI) is a lookup table which, amongst other things, provides the geospatial coordinates for certain Safeguard and NGERS reporting organisations. There is an additional data set which shows the number of employees for certain facilities for each financial year reporting period.

Employee numbers can be integrated into the existing Snapshot tool to allocate emissions within a specific ANZSIC category to an organisation.

This data is only used for facilities when safeguard and NGERS data is unavailable.

4.2.4 Hospitals, aged care and schools

These are national data sets which provide the number of beds (hospitals and aged care) or students (schools) for each individual facility. A conversion factor is applied to convert the number of beds/students to estimated employees.

Employee numbers can be integrated into the existing Snapshot tool to allocate emissions within a specific ANZSIC category to an organisation.

This data is always used since these organisations are not required to report their emissions.

4.2.5 Open street maps

This data set contains geospatial vectors for specific facilities and provides a corresponding category (i.e. supermarkets). This is a very diverse data set which contains anything from supermarkets to military bases. Based on the geospatial vectors, the land size can be derived and each facility can be assigned to a municipality. A separate conversion factor is applied to each category in order to estimate the number of employees. For example, a supermarket covering a large land area (i.e. Woolworths) is likely to have a bigger carbon footprint than a smaller supermarket (i.e. Foodworks).

Employee numbers can be integrated into the existing Snapshot tool to allocate emissions within a specific ANZSIC category to an organisation.

This data is generally always used for organisations that are not required to report their emissions, and for whom we don't have access to reliable national data sets (such as we have with government schools and hospitals).

5. References

Table 6: Basic Metrics Data References

Description	Source	Location	URL
Population	Australian Bureau of Statistics	N/A	https://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
Dwelling Type	Australian Bureau of Statistics	N/A	https://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
SEIFA	Australian Bureau of Statistics	N/A	https://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
Jobs INDP4 and OCCP1	Australian Bureau of Statistics	N/A	https://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
Commercial jobs and building approvals	Economic Indicators	N/A	https://content.id.com.au/state-of-the-regions-economic-indicators

Table 7: Concordances References

Description	Source	Location	URL
Local Government Area Concordances	Australian Bureau of Statistics	N/A	https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1270.0.55.003June%202020?OpenDocument
Postcode Concordances	Australian Bureau of Statistics	N/A	https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1270.0.55.003June%202020?OpenDocument
SA4 Concordances	Australian Bureau of Statistics	N/A	https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1270.0.55.003June%202020?OpenDocument
CED Concordances	Australian Bureau of Statistics	N/A	https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1270.0.55.003June%202020?OpenDocument
IBRA7 Concordances	Australian Department of Environment and Energy	N/A	http://www.environment.gov.au/land/nrs/science/ibra/ibra7-codes
Schools Concordances	Australian Schools List	N/A	https://asl.acara.edu.au/school-search

Table 8: Stationary Energy Data References

Description	Source	Location	URL
QLD LGA electricity consumption data	Energex	N/A	https://www.energex.com.au/about-us/company-information/our-network/data-to-share/energy-usage-data-to-share
NSW LGA electricity consumption data	Ausgrid	N/A	https://www.ausgrid.com.au/Industry/Our-Research/Data-to-share/Average-electricity-use
VIC LGA electricity consumption data	United	N/A	https://www.unitedenergy.com.au/network-management/network-data/
VIC LGA electricity consumption data	Ausnet	N/A	https://www.ausnetservices.com.au/electricity/network-information/energy-usage-data
NSW LGA gas consumption data	Jemena	N/A	https://data.peclet.com.au/explore/dataset/jemena-average-gas-consumption-lga-level/table/
State level stationary energy activity data by sector	Australian Energy Statistics	Table F	https://www.energy.gov.au/publications/australian-energy-update-2022
Natural Gas Availability	Australian Gas Networks	N/A	https://www.australiangasnetworks.com.au/
Tas Gas Pipeline Locator	Tas Gas Networks	N/A	
WA Gas Pipeline Network Coverage Maps	ATCO	N/A	

Table 9: Key Emitters Data References

Description	Source	Location	URL
Safeguard Mechanism	Safeguard Mechanism	N/A	https://www.cleanenergyregulator.gov.au/NGER/The-safeguard-mechanism/safeguard-data/safeguard-facility-reported-emissions
National Pollutants Inventory Lookup	National Pollutants Inventory	N/A	https://www.dcceew.gov.au/environment/protection/npi
National Pollutants Inventory Employees	National Pollutants Inventory	N/A	https://www.dcceew.gov.au/environment/protection/npi
NGERS	National Greenhouse and Energy Reporting	N/A	https://www.cleanenergyregulator.gov.au/NGER/National%20greenhouse%20and%20energy%20reporting%20data/Corporate%20emissions%20and%20energy%20data

Victorian government Schools	Victorian Government	N/A	https://www.education.vic.gov.au/Documents/about/department/schoolsandenrolments.xlsx
New South Wales government Schools	New South Wales Government	N/A	https://data.cese.nsw.gov.au/data/dataset/nsw-public-schools-master-dataset
Queensland government Schools	Queensland government	N/A	https://www.data.qld.gov.au/dataset/state-school-enrolments-by-school-and-year-level-february-census/resource/4d8a3dcc-30c7-40dd-be11-f13e97e26414
Tasmanian government Schools	Tasmanian government	N/A	https://publicdocumentcentre.education.tas.gov.au/library/Shared%20Documents/Key-Data-2022.pdf
Aged Care	Australian Government	N/A	https://www.gen-agedcaredata.gov.au/resources/access-data/2023/september/aged-care-service-list-30-june-2023
Hospitals	Hospital Resources 2021-22 data tables	Table A.S1	https://www.aihw.gov.au/reports-data/myhospitals/content/data-downloads
Open Street Maps	Geofabrik	N/A	https://download.geofabrik.de/australia-oceania.html

Table 10: Transport Data References

Description	Source	Location	URL
Registered motor vehicles by vehicle type,state of registration, registered postcode and motive power	Australian Government	N/A	https://data.gov.au/dataset/ds-dga-c34b68b7-b482-48c4-86ad-a426e22dd761/distribution/dist-dga-29afde73-4971-440e-a1e3-7d549f391569/details?q=
Activity data (total distance) by transport mode and boundary type	Google EIE	N/A	https://insights.sustainability.google/
Australian Domestic Airline Activity – Time Series	BITRE	N/A	https://www.bitre.gov.au/publications/ongoing/domestic_airline_activity-time_series
Airport Traffic Data	BITRE	N/A	https://www.bitre.gov.au/publications/ongoing/airport_traffic_data
ICAO Carbon Emissions Calculator	ICAO	N/A	https://www.icao.int/environmental-protection/Carbonoffset/Pages/default.aspx

Table 11: Waste Data References

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

Table 12: Agriculture Data References

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

Table 13: Land Use Data References

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

Table 14: Australia's National Greenhouse Accounts Data References

Description	Source	Location	URL
Australia's National Greenhouse Accounts	Australia's National Greenhouse Accounts	N/A	https://ageis.climatechange.gov.au/

Table 15: Emissions Factors References

Description	Source	Location	URL
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
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
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
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
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
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
Rail Emissions Intensity Factors	BITRE Trainline 7		https://www.bitre.gov.au/publications/2019/trainline-7
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
Enteric Fermentation Emissions Factors	IPCC	Table 4-3 and Table 4-4	https://www.ipcc-nggip.iges.or.jp/public/gl/invs6c.html
Manure Management Emissions Factors	IPCC	Table 4-5 and Table 4-6	https://www.ipcc-nggip.iges.or.jp/public/gl/invs6c.html
Annual Carbon Losses in Biomass due to Disturbances	IPCC	N/A	https://www.ipcc-nggip.iges.or.jp/public/gl/invs6c.html
Above-Ground Biomass in Forests	IPCC	N/A	https://www.ipcc-nggip.iges.or.jp/public/gl/invs6c.html
Ratio of Below-Ground Biomass to Above-Ground Biomass	IPCC	N/A	https://www.ipcc-nggip.iges.or.jp/public/gl/invs6c.html