Quarterly Update of Australia’s National Greenhouse Gas Inventory: September 2022
Incorporating preliminary emissions up to December 2022

Australia’s National Greenhouse Accounts
Preface

The Quarterly Update provides estimates of Australia’s national inventory of greenhouse gas emissions up to the September quarter of 2022, and preliminary estimates of emissions for the year to December 2022.

Emissions for the year to September 2022 are estimated to be 490.5 Mt CO₂-e, up 0.1% or 0.3 Mt CO₂-e on the previous year. This change in emissions over the year to September 2022 reflects movements across sectors, including:

- Ongoing reductions in emissions from electricity as renewable energy uptake continues (down 3.1%; 5.1 Mt CO₂-e);
- Decreased fugitive emissions (down 3.0%; 1.5 Mt CO₂-e), reflecting decreased production of LNG at multiple facilities impacted by scheduled maintenance and industrial action;
- Increased transport emissions (up 4.3%; 3.8 Mt CO₂-e) reflecting the ongoing recovery from COVID related travel restrictions;
- Increased emissions from stationary energy (excluding electricity) (up 0.7%; 0.7 Mt CO₂-e); driven primarily by increased activity in the chemical manufacturing sector; and
- Increased emissions from agriculture (up 3.2%; 2.5 Mt CO₂-e) due to the continuing recovery from drought driving increases in livestock numbers and crop production.

Figure P1: Emissions²,³, by quarter, September 2005 to September 2022 (including preliminary December 2022)

Source: Department of Climate Change, Energy, the Environment and Water

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² Carbon dioxide equivalent (CO₂-e) emissions values are calculated using Global Warming Potential (GWP) values for a 100 year time horizon from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5). See Section 4: Technical Notes for further detail. Actual emissions are presented when comparing emissions over the year or relative to a base year. This is consistent with our international reporting requirements.

³ ‘Actual’, ‘seasonally adjusted, ‘weather normalised’ and ‘trend’ are defined in Section 4: Technical notes.

² National emissions levels are inclusive of all sectors of the economy, including Land Use, Land use Change and Forestry (LULUCF) and includes the application of the IPCC’s natural disturbance provision.
Emissions in the year to September 2022 were 21.0% below emissions for the year to June 2005 (the baseline year for Australia’s 43% single-year 2030 target under the Paris Agreement). In addition to this single-year target, Australia has also committed to an emissions budget over the period 2021-2030. Australia is 23% through the Paris Agreement target period and has used 25% of the emissions budget to 2030. Cumulatively, over the 9 quarters since the start of the budget period, Australia has emitted 1,103 Mt CO$_2$-e, leaving 3,278 Mt CO$_2$-e remaining$^4$.

On a quarterly basis, national emission levels for the September quarter 2022 increased 0.3% or 0.3 Mt CO$_2$-e on the previous quarter in trend terms (Figure P1). The trend result for the September quarter 2022 reflects increases across the transport, fugitive emissions, agriculture and stationary energy (excluding electricity) sectors. These increases were partially offset by decreases across the electricity, industrial processes, and Land Use, Land Use Change, and Forestry (LULUCF) sectors.

In the year to September 2022, the emissions intensity of the economy continued its long term decline, down 49.3% on 2005 levels. Emissions per capita were 38.9% lower than 2005.

National emissions are preliminarily estimated to be 490 Mt CO$_2$-e in the year to December 2022, a decrease of 0.3% on the previous year to December. On a quarterly basis, national emissions are preliminarily estimated to be 123 Mt CO$_2$-e in trend terms, a decrease of 0.1% on the previous quarter.

$^4$ Australia’s progress against its emissions budget is based on current emissions estimates and is subject to change as more complete and accurate information becomes available, and in response to changes in estimation methods and international reporting requirements.
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1. Overview

Table 1: National Greenhouse Gas Inventory\(^5\), September quarter 2022, quarterly and annual change

<table>
<thead>
<tr>
<th></th>
<th>September quarter 2022</th>
<th>Year to September 2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarterly change – seasonally adjusted and weather normalised(^6)</td>
<td>1.2%</td>
<td></td>
</tr>
<tr>
<td>Quarterly change – seasonally adjusted and weather normalised – trend(^6)</td>
<td>0.3%</td>
<td></td>
</tr>
<tr>
<td>Annual Change</td>
<td></td>
<td>0.1%</td>
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</tbody>
</table>

Table 2: National Greenhouse Gas Inventory, preliminary December quarter 2022, quarterly and annual change

<table>
<thead>
<tr>
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<th>Preliminary December quarter 2022</th>
<th>Preliminary year to December 2022</th>
</tr>
</thead>
<tbody>
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<td>Quarterly change – seasonally adjusted and weather normalised(^6)</td>
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<tr>
<td>Quarterly change – seasonally adjusted and weather normalised – trend(^6)</td>
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<tr>
<td>Annual Change</td>
<td></td>
<td>-0.3%</td>
</tr>
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</table>

Summary of emissions in the September quarter 2022

National emissions for the September quarter 2022 increased 0.3% or 0.3 Mt CO\(_2\)-e on the previous quarter in trend terms. Emissions were higher in the September quarter 2022 in the *transport*, *fugitive emissions*, *agriculture* and *stationary energy (excluding electricity)* sectors. These increases were partially offset by decreases across the *electricity*, *industrial processes*, and *Land Use, Land Use Change, and Forestry (LULUCF)* sectors.

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\(^5\) National emissions levels are inclusive of all sectors of the economy, including *Land Use, Land Use Change and Forestry (LULUCF)*.

\(^6\) ‘Actual’, ‘seasonally adjusted’, ‘weather normalised’ and “trend” are defined in Section 4: Technical notes.
Emissions of individual gases

Carbon dioxide (CO$_2$) emissions contribute the largest share – approximately 68% – of total emissions in Australia. In trend terms, emissions in the September 2022 quarter have declined by 29.6% to 81.5 million tonnes (Mt), since the peak in the December 2006 quarter (Figure 2). The most important factors causing this long term decline in carbon dioxide emissions include the continuing shift in the generation of electricity from coal towards renewable fuel sources, and decreasing emissions in the Land sector. Against these downward forces, long term growth in the economy and transport activity, as well as the expansion of LNG exports have placed upward pressure on this time series.

Methane (CH$_4$) emissions contribute approximately 26% of aggregate emissions in Australia. Overall methane emissions in the quarter ending September 2022 have declined by 13.9% in trend terms since the September 2005 quarter. Trends in methane emissions are dominated by events in Agriculture such as drought, Fugitive emissions related to coal, oil and gas production levels, and the Land and Waste sectors.

Nitrous oxide (N$_2$O) emissions contribute around 4% of aggregate emissions in Australia. Overall, nitrous oxide emissions in the September 2022 quarter have declined by 2.4% since the September 2005 quarter. Trends in nitrous oxide emissions are sensitive to events in the Agriculture sector such as synthetic fertilizer use and biomass burning in the Land sector.

Other gases comprising hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF$_6$) contribute the balance of total aggregate emissions (around 2%). Growth in emissions of other gases is primarily driven by consumption of refrigerants in refrigeration and airconditioning.

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*Figure 1: Emissions, by quarter, September 2005 to September 2022*

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7 ‘Seasonally adjusted’, ‘weather normalised’, and ‘trend’ are defined in Section 4: Technical notes
equipment. Overall, emissions of other gases have more than doubled (up 122.1%) in trend terms since the September 2005 quarter.

Figure 2: Emissions by quarter and gas, trend, September 2005 to September 2022

Source: Department of Climate Change, Energy, the Environment and Water

Summary of annual GHG emissions

Emissions for the year to September 2022 are estimated to be 490.5 Mt CO₂-e. The 0.1% or 0.3 Mt CO₂-e increase in emissions over the year to September reflects annual increases in emissions from the transport, agriculture, waste and stationary energy sectors. These increases were partially offset by decreases in emissions from the electricity, fugitive emissions and industrial processes sectors (Table 3).
Table 3: Actual annual emissions, by sector, for the year to September 2021 and 2022

<table>
<thead>
<tr>
<th>Sector</th>
<th>Annual emissions (Mt CO₂-e) year to September 2021</th>
<th>Annual emissions (Mt CO₂-e) year to September 2022</th>
<th>Change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy – Electricity</td>
<td>162.0</td>
<td>157.0</td>
<td>-3.1%</td>
</tr>
<tr>
<td>Energy – Stationary energy excluding electricity</td>
<td>103.7</td>
<td>104.5</td>
<td>0.7%</td>
</tr>
<tr>
<td>Energy – Transport</td>
<td>89.3</td>
<td>93.1</td>
<td>4.3%</td>
</tr>
<tr>
<td>Energy – Fugitive emissions</td>
<td>49.3</td>
<td>47.9</td>
<td>-3.0%</td>
</tr>
<tr>
<td>Industrial processes and product use</td>
<td>33.0</td>
<td>32.5</td>
<td>-1.3%</td>
</tr>
<tr>
<td>Agriculture</td>
<td>78.9</td>
<td>81.4</td>
<td>3.2%</td>
</tr>
<tr>
<td>Waste</td>
<td>13.4</td>
<td>13.6</td>
<td>1.5%</td>
</tr>
<tr>
<td>Land Use, Land Use Change and Forestry</td>
<td>-39.4</td>
<td>-39.5</td>
<td>0.0%</td>
</tr>
<tr>
<td>National Inventory Total</td>
<td>490.2</td>
<td>490.5</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

Figure 3: Share of total emissions, by sector, for the year to September 2022

Source: Department of Climate Change, Energy, the Environment and Water

Over the year to September 2022 the 3.1% decrease in emissions from the electricity sector reflected a decrease of 4.9% in coal generation and an increase of 19.0% in renewable generation in the National Electricity Market (NEM).

Transport emissions increased 4.3% over the year to September 2022, reflecting a return towards normal levels of transport activity after the impacts of the widespread COVID related restrictions on movement in the 2022 financial year. Petrol consumption increased 2.2% over the year, reflecting a rebound in passenger car travel, while consumption of diesel was higher by 2.6%. Consumption of
domestic jet fuel also increased by 42.2%, reflecting a surge in demand for domestic air travel following the removal of domestic and international travel restrictions.

Emissions from the *agriculture* sector increased 3.2% to 81.4 Mt CO$_2$-e, reflecting a continuation of the recent changes in rainfall, cropping and livestock numbers.

In the year to December 2022, the preliminary estimate for total emissions is 490 Mt CO$_2$-e. This would be a decrease of 0.3% or 1.4 Mt CO$_2$-e on the year to December 2021. This estimate will be finalised with the publication of the December 2022 Quarterly Update in May 2023.

**Long term sectoral trends**

The most important sectoral drivers of Australia’s long-term emissions trend have been:

- *Land Use, Land Use Change and Forestry (LULUCF)* – where emissions have decreased by the largest margin of any sector since 2005 (145.0% or 127.2 Mt CO$_2$-e) due to reductions in land clearing and native forest harvesting, increases in plantations and native vegetation, and improvements in soil carbon;

- *Electricity* – where emissions have decreased 20.7% or 40.9 Mt CO$_2$-e since 2005. After decades of strong growth, emissions peaked in 2009 and have since fallen 25.8%. This reflects accelerating renewables deployment and gradual displacement of coal as a fuel source;

- *Stationary energy (excluding electricity)* – which has experienced the largest growth of any sector in percentage terms since 2005. Emissions have increased 27.2% or 22.4 Mt CO$_2$-e driven, in particular, by continued growth in the export of LNG;

- *Transport* – where emissions have increased 13.9% or 11.3 Mt CO$_2$-e since 2005, despite recent volatility due to the impacts of the COVID pandemic;

- *Fugitives* – where emissions have increased 11.4% or 4.9 Mt CO$_2$-e since 2005. Emissions were relatively stable until 2012 but have increased strongly as a result of the growth of the LNG industry; and

- *Agriculture* – where emissions have declined by 4.9% or 4.2 Mt CO$_2$-e since 2005, in line with declining sheep and cattle populations.

The changes in emissions from each sector from the year to September 2005 to 2022 in percentage terms are presented in Figure 4.
Figure 4: Percentage change in emissions, by sector, since 2005

Source: Department of Climate Change, Energy, the Environment and Water

2. Sectoral Analysis

2.1 Energy – Electricity

*Electricity* generation is the largest source of emissions in the national inventory, accounting for 32.0% of emissions in the year to September 2022 (Figure 3).

*Electricity* sector emissions are continuing to decline over the long term, down 25.8% (54.7 Mt CO₂-e) from the peak recorded in the year to September 2009 (Data Table 1A).

Over the September quarter, emissions in the *electricity* sector decreased 1%, on a trend basis (Figure 5). This reflected a 0.8% decline in coal generation and a consequent increase of 3.8% in renewable generation.

Over the year to September 2022, ongoing substitution of renewable energy for fossil fuel power sources resulted emissions from *electricity* decreasing 3.1% in actual terms. Coal generation declined 4.9% compared to the year to September 2021, while generation from renewables increased 19% in actual terms.
Figure 5: Electricity sector emissions, by quarter, September 2005 to September 2022

Source: Department of Climate Change, Energy, the Environment and Water, Australian Energy Market Operator (AEMO, 2022), obtained using NEM-Review software

National Electricity Market (NEM) emissions

Emissions in the NEM for the December quarter 2022 decreased 1.7% on a trend basis compared with the previous quarter, reflecting reductions in metered demand as milder weather conditions returned (Figure 6). Over the year to December 2022 emissions in the NEM decreased 3.8%, driving NEM emissions to the lowest levels on record.

Figure 6: NEM electricity emissions, by quarter, December 2005 to December 2022

Source: Department of Climate Change, Energy, the Environment and Water, Australian Energy Market Operator (AEMO, 2022), obtained using NEM-Review software
For the December 2022 quarter, generation from renewables increased 2.5%, while generation from gas decreased 6.6% and coal decreased 0.9%, in trend terms (Figure 7).

Figure 7: Cumulative change in electricity generation in the NEM, trend, by fuel, by quarter, December 2010 to December 2022

Note: AEMO data on small solar is available from 2016 onwards.
Source: Department of Climate Change, Energy, the Environment and Water, Australian Energy Market Operator (AEMO, 2022), obtained using NEM-Review software

2.2 Energy – Stationary energy excluding electricity

Stationary energy excluding electricity includes emissions from direct combustion of fuels, predominately from the manufacturing, mining, residential and commercial sub-sectors.

In the year to September 2022, stationary energy excluding electricity accounted for 21.3% of Australia’s national inventory (Figure 3).

Emissions from stationary energy excluding electricity in the September quarter of 2022 increased 0.3% (0.1 Mt CO$_2$-e) in trend terms compared with the previous quarter. This was primarily driven by increased activity in the chemical manufacturing sector. Emissions over the year to September 2022 increased 0.7% (0.7 Mt CO$_2$-e) in actual terms, compared with the previous year (Figure 8).

An important driver of emissions trends in stationary energy over the last 5 years has been the production of LNG for export. Figure 9 shows that LNG exports have increased by 205% compared to the year to September 2015, before the start of the rapid ramp up.
Figure 8: Stationary energy excluding electricity emissions, actual and trend, by quarter, September 2005 to September 2022

Figure 9: LNG exports, by quarter, September 2010 to September 2022
2.3 Energy – Transport

The transport sector includes emissions from the direct combustion of fuels in transportation by road, rail, domestic aviation and domestic shipping. The main fuels used for transport are automotive gasoline (petrol), diesel oil, liquefied petroleum gas (LPG) and aviation turbine fuel.

In the year to September 2022, transport accounted for 19.0% of Australia’s national inventory (Figure 3).

Emissions from transport over the year to September 2022 increased 4.3% in actual terms, compared with the previous year (Figure 10). This was driven by a 42.2% increase in domestic jet fuel consumption, a 2.6% increase in diesel consumption, and a 2.2% increase in petrol consumption over the year to September 2022 (Figure 11). This year on year increase reflects the ongoing recovery from the impacts of COVID related lockdowns.

Emissions in the September 2022 quarter increased 1.3% in trend terms on the previous quarter as transport activity continues to return to pre-pandemic levels. This reflects the removal of all COVID related restrictions on movement in the June 2022 quarter8.

Figure 10: Transport emissions, actual and trend, by quarter, September 2005 to September 2022

Source: Department of Climate Change, Energy, the Environment and Water

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2.4 Energy – Fugitive emissions

Fugitive emissions occur during the production, processing, transport, storage, transmission and distribution of fossil fuels. These include coal, crude oil and natural gas. Emissions from decommissioned underground coal mines are also included in this sector.

Fugitive emissions in the September quarter increased 1.0% in trend terms.

In the September 2022 quarter, LNG production was lower by 5.7%, while coal production was higher by 5.8%. The increase in coal production over the quarter reflects a return towards usual levels of production following the impacts of labour shortages and heavy rainfall events in New South Wales and Queensland in the June 2022 Quarter.

Annual emissions in this sector decreased 3.0% in actual terms over the year to September 2022 (Figure 12). This was driven by reduced production in coal mining as a result of floods in the 2022 year offsetting higher production and emissions in the oil and gas sector.
2.5 Industrial processes and product use

Emissions in industrial processes and product use include greenhouse gases emitted as by-products of the production of chemicals, metals and minerals, as well as emissions of synthetic greenhouse gases used in products such as refrigerators and air conditioners.

In the year to September 2022, industrial processes and product use accounted for 6.6% of Australia’s national inventory. Emissions decreased 1.3% (0.4 Mt CO$_2$-e) in actual terms over the year to September 2022, driven by lower emissions of hydrofluorocarbon (HFC) refrigerants and lower aluminum production. Major subcategories are shown in Figure 13.

Emissions from industrial processes and product use decreased 0.3% from the previous quarter in trend terms, driven by a 6.6% decrease in steel production.

Long-term trends in industrial processes and product use emissions are primarily driven by increased use of HFC refrigerants. The sharp drop in metal industry emissions in the year to September 2009 reflects lower steel production during the global financial crisis.
2.6 Agriculture

Emissions from *agriculture* include methane, nitrous oxide and carbon dioxide. Methane and nitrous oxide emissions are estimated for enteric fermentation and manure management in livestock. They are also estimated for rice cultivation, agricultural soils and field burning of agricultural residues. The CO₂ emissions are reported from the application of urea and lime.

In the year to September 2022, *agriculture* accounted for 16.6% of Australia’s national inventory (Figure 3). Emissions from *agriculture* increased 3.2% (2.5 Mt CO₂-e) in actual terms over the year to September 2022, primarily driven by increasing livestock numbers and crop production (Figure 14).
Favourable conditions brought record crop production in 2021-22, with an associated increase in emissions from crop residues and fertiliser use. For many crops this is expected to continue into 2022-23. Herd and flock numbers have continued to grow, and are forecast to recover to pre-drought levels.

2.7 Waste

The waste sector includes emissions from landfills, wastewater treatment, waste incineration and the biological treatment of solid waste. Emissions largely consist of methane, which is generated when organic matter decays under anaerobic conditions.

In the year to September 2022, waste accounted for 2.8% of Australia’s national inventory (Figure 3). Emissions from waste increased 1.5% (0.2 Mt CO₂-e) over the year to September 2022 in actual terms (Figure 15). The increasing trend over the year was primarily driven by a decrease in methane capture at landfills.

Source: Department of Climate Change, Energy, the Environment and Water

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2.8 Land Use, Land Use Change and Forestry

The Land Use, Land Use Change and Forestry (LULUCF) sector of the national inventory includes estimates of net anthropogenic emissions for forests and agricultural lands and changes in land use.

In the year to September 2022, the LULUCF sector\(^\text{11}\) accounted for -8.0% of Australia’s national inventory – a net sink (Figure 3).

Net emissions for the LULUCF sector in the year to September 2022 are estimated to be -39.5 Mt CO\(_2\)-e. The magnitude of this net sink remained flat on the previous twelve months in actual terms (Figure 16).

\(^{11}\) LULUCF includes Forest converted to other uses, Forest land remaining forest land, Land converted to forest land, Grassland remaining grassland (including Wetlands and Settlements) and Cropland remaining cropland.
Figure 16: LULUCF net anthropogenic emissions, by sub-sector, year to September, 2005 to 2022

Source: Department of Climate Change, Energy, the Environment and Water
3. Emissions per capita and per dollar of GDP

In the year to September 2022, the emissions intensity of the economy continued its long term decline, down 49.3% on 2005 levels. National inventory emissions per dollar of real GDP fell from 0.4 kg CO\(_2\)-e per dollar in the year to September 2005 to 0.2 kg CO\(_2\)-e per dollar in the year to September 2022 (Figure 17).

Australia’s real GDP (chain volume measures) also experienced significant growth over this period, expanding from $1.4 trillion in the year to September 2005 to around $2.2 trillion in the year to September 2022, an increase of 59.3%.

Over the period from September 2005 to September 2022, Australia’s population grew strongly from 20.2 million to around 26.1 million, an increase of 29.0%. National inventory emissions per capita were 18.9 t CO\(_2\)-e per person in the year to September 2022, a 38.9% decline from 30.9 t CO\(_2\)-e per person in the year to September 2005.

Figure 17: Actual emissions per capita and per dollar of real GDP, year to September 2005 to 2022

Source: Department of Climate Change, Energy, the Environment and Water

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12 Emissions per capita and per dollar of real GDP levels are inclusive of all sectors of the economy, including Land Use, Land Use Change and Forestry (LULUCF)
4. Technical notes

5.1 Quarterly Coverage

The Quarterly Update uses emissions estimates based on Australia’s United Nations Framework Convention on Climate Change (UNFCCC) inventory time series. Australia’s UNFCCC inventory will be used to track progress towards Australia’s commitments under the Paris Agreement, including its achievement of net zero emissions by 2050. In July 2022, the Australian Government formalised its commitment to reduce emissions by 43% on 2005 levels by 2030 by submitting a new Nationally Determined Contribution (NDC) under the Paris Agreement to the UNFCCC. The 2030 and 2050 targets have also been legislated in the Climate Change Act 2022.

The inventory used by Australia to acquit its Paris Agreement targets includes anthropogenic sources and sinks across Australia’s economy. This comprehensive approach is consistent with the one adopted by all parties to the UNFCCC and ensures Australia’s accounting is complete and comparable with other reporting party inventories.

5.2 International guidelines

The Quarterly Update has been prepared in accordance with the international guidelines agreed for use for the Paris Agreement including the IPCC 2006 Guidelines for the Preparation of National Greenhouse Gas Inventories and, where applicable, the 2019 IPCC Refinement to the 2006 IPCC Guidelines.

The Quarterly Update reports on the national inventory with the application of the IPCC’s natural disturbances provision, consistent with Australia’s NDC submission that indicated it would meet its emission reduction commitments using this provision.

The national inventory prepared without the application of the natural disturbances provision is reported in the Australian Government’s National Inventory Report submitted to the UNFCCC each year. That submission provides full details of estimates of annual emissions from bushfires and sequestration from subsequent biomass recovery.

5.3 Greenhouse gases

Emissions are expressed on a CO$_2$-e basis using the GWP weighting factors indicated in Table 4. As greenhouse gases vary in their radiative activity and in their atmospheric residence time, converting emissions into CO$_2$-e allows the integrated effect of emissions of the various gases to be compared.

Commencing with the Quarterly Update of March 2020, the Department has applied the 100-year time GWP values from the IPCC Fifth Assessment Report (AR5) to estimate emissions, consistent with rules adopted under the UNFCCC Paris Agreement (Decision 18/CMA.1 Annex 2.D Paragraph 37). This approach will also be used to track Australia’s progress towards its Paris Agreement NDC.

Paris Agreement update to Global Warming Potential for emission estimation

According to Paris Agreement Decision 18/CMA.1 Annex 2.D Paragraph 37 - “Each Party shall use the 100-year time-horizon global warming potential (GWP) values from the IPCC Fifth Assessment Report, or 100-year time-horizon GWP values from a subsequent IPCC assessment report as agreed upon by the CMA, to report aggregate emissions and removals of GHGs, expressed in CO$_2$ eq.”
Prior to the December 2020 Quarterly Update, the GWPs used were the 100-year time-horizon GWPs contained in the 2007 IPCC Fourth Assessment Report of Climate Science (AR4), in accordance with previous UNFCCC decisions.

Table 4 compares the IPCC Fifth and Fourth Assessment Reports’ 100-year GWPs.

Table 4: Comparison of the IPCC Fifth and Fourth Assessment Reports’ 100-year GWPs

<table>
<thead>
<tr>
<th>Major greenhouse gases</th>
<th>4th Assessment Report GWP (Table 2.14)</th>
<th>5th Assessment Report GWP (Table 8.A.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide (CO₂)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Methane (CH₄)</td>
<td>25</td>
<td>28</td>
</tr>
<tr>
<td>Nitrous oxide (N₂O)</td>
<td>298</td>
<td>265</td>
</tr>
<tr>
<td>Perfluorocarbon - CF₄</td>
<td>7,390</td>
<td>6,630</td>
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<td>Perfluorocarbon – C₂F₆</td>
<td>12,200</td>
<td>11,100</td>
</tr>
<tr>
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<td>675</td>
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<td>92</td>
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<td>794</td>
<td>804</td>
</tr>
<tr>
<td>Sulphur hexafluoride (SF₆)</td>
<td>22,800</td>
<td>23,500</td>
</tr>
</tbody>
</table>

Australia’s emissions of the greenhouse gas nitrogen trifluoride (NF₃) are considered negligible and are not estimated.

5.4 Quarterly methodology and growth rates

Emission estimates have been compiled by the Department using the estimation methodologies incorporated in the Australian Greenhouse Emissions Information System (AGEIS) and documented in the National Inventory Report.
The estimates are calculated using the latest national inventory data and indicators from external data sources (listed in Section 5.6). These data are used to determine growth rates, which are applied to estimate quarterly emissions growth.

Quarterly growth rates are calculated as the percentage change between the estimates for the previous quarter and the current quarter. Annual growth rates are calculated as the percentage change between the estimates for the twelve months to the end of the equivalent quarter in the previous year, and the twelve months to the end of the current quarter.

5.5 Recalculations

Periodic recalculations of the quarterly emission estimates are undertaken as more complete and accurate information becomes available, and in response to changes in estimation methods and international reporting requirements.

Recalculations are undertaken consistent with international guidelines, are estimated on a time series consistent basis and, in the context of the National Inventory Report, are subject to annual international expert review.

Recalculations since the June Quarter 2022

The recalculations since the June 2022 edition of the Quarterly Update for the years 2005 and 2020 to 2022, by sector in Mt CO₂-e, are shown in Table 5.

Recalculations in this Quarterly Update include updates to indicators used to derive emissions estimates in the quarters beyond the latest official inventory year reported in the Australian Government’s annual National Inventory Report submitted under the UNFCCC.
Table 5: Recalculations (Mt CO$_2$-e) since the June 2022 Quarterly Update, by sector, 2005 and 2020 to 2022

<table>
<thead>
<tr>
<th>Sector</th>
<th>FY 2005</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>FY 2020</th>
<th></th>
<th></th>
<th></th>
<th>FY 2021</th>
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<th>FY 2022</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Electricity</td>
<td>0.3</td>
<td>-1.9</td>
<td>0.6</td>
<td>0.9</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>-0.2</td>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.2</td>
<td>-0.1</td>
<td>0.0</td>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stationary energy (excluding electricity)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>-0.3</td>
<td>-0.2</td>
<td>-0.2</td>
<td>-0.2</td>
<td>0.4</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
<td>0.7</td>
<td>0.8</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>-0.3</td>
<td>-0.4</td>
<td>-0.4</td>
<td>-0.4</td>
<td>-0.3</td>
<td>-0.4</td>
<td>-0.3</td>
<td>-0.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fugitive emissions</td>
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<td>0.0</td>
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<td>0.0</td>
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<td>0.0</td>
<td>-0.1</td>
<td>-0.5</td>
<td>-0.7</td>
<td>-0.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial processes and product use</td>
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<td>0.0</td>
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</tr>
<tr>
<td>Waste</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
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<td>0.2</td>
<td>0.2</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>LULUCF</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>0.3</td>
<td>-1.9</td>
<td>0.6</td>
<td>1.0</td>
<td>-0.2</td>
<td>-0.1</td>
<td>-0.2</td>
<td>-0.1</td>
<td>0.4</td>
<td>0.6</td>
<td>0.6</td>
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<td>0.1</td>
<td>0.1</td>
<td></td>
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</tr>
</tbody>
</table>

5.6 Source Data

Preliminary activity data are obtained under the National Greenhouse and Energy Reporting Scheme (NGERS) and from a range of publicly available sources, principally:

5.7 Actual time series

The ABS defines an original time series as showing ‘the actual movements in the data over time’. The actual time series in this report are equivalent to an original time series and are used when discussing an annual time-series.

5.8 Seasonal adjustment analysis

The ABS defines seasonal adjustment as follows: ‘A seasonally adjusted time-series is a time-series with seasonal component removed. This component shows a pattern over one year or less and is systemic or calendar related.’

The actual quarterly data have been adjusted using Demetra to remove the effects of seasonal factors. Demetra is a standard seasonal adjustment tool, consistent with methods applied by the ABS.

5.9 Weather normalisation

The seasonally adjusted estimates are further adjusted to correct for the effects of variations around average seasonal temperatures. This process is termed ‘weather normalisation’ and is designed to provide a clearer indication of the underlying trends in the emissions data.

Seasonal temperatures are an important predictor of emissions in Australia due to their influence on demand for electricity for heating and cooling (air conditioning).

The weather normalisation methodology is based on the Bureau of Meteorology concept of ‘heating and cooling degree days,’ and is applied to total emissions (excluding LULUCF) and the electricity sector. The methodology is described in detail in ‘Section 7: Special Topic’ of the December 2011 edition of the Quarterly Update.
5.10 Trend analysis

The trend series provides the best indication of underlying movements in the inventory by smoothing short term fluctuations in the seasonally adjusted and weather normalised series, caused for example, by extreme weather events such as floods or fires. The trend time series is estimated using the Demetra tool. More information on trend analysis is available on the ABS website http://www.abs.gov.au/websitedbs/D3310114.nsf/home/Time+Series+Analysis:+The+Basics.

5.11 Quarterly uncertainty

For all sectors the Department’s assessment is that the 90% confidence interval for the national inventory is ± 5.3% (i.e. there is a 90% probability that future revisions will be limited to ± 5.3% of the current estimate). More information on uncertainty analysis is available in the National Inventory Report Volume 3 https://www.dcceew.gov.au/sites/default/files/documents/national-inventory-report-2020-volume-3.pdf.

5.12 Sectoral emissions sources and sinks

Energy

Electricity

- Emissions from the combustion of fuel used to generate electricity for public use.

Stationary energy excluding electricity

- **Energy industries**: petroleum refining, gas processing and solid fuel manufacturing (including coal mining and oil/gas extraction and processing).
- **Manufacturing industries and construction**: direct emissions from the combustion of fuel to provide energy used in manufacturing such as steel, non-ferrous metals, chemicals, food processing, non-energy mining and pulp and paper.
- **Other sectors**: energy used by the commercial, institutional, residential sectors as well as fuel used by the agricultural, fishery and forestry equipment. This also includes all remaining fuel combustion emissions associated with military fuel use.

Transport

- **Road transport**: passenger vehicles, light commercial vehicles, trucks, buses and motorcycles.
- **Domestic air transport**: commercial passenger and light aircraft on domestic routes using either aviation gasoline or jet kerosene. International air transport is reported but not included in Australia’s total emissions (in line with international guidelines).
- **Coastal shipping**: domestic shipping and small craft. International shipping is reported but not included in Australia’s total emissions (in line with international guidelines).
- **Rail transport**: railways, but not electric rail, where fuel combustion is covered under the electricity sector.
- **Transmission of natural gas.**
Fugitive emissions

Emissions, other than those attributable to energy use, from:

- **Solid fuels**: CO$_2$ and CH$_4$ from coal mining activities, post-mining and decommissioned mines and CO$_2$, CH$_4$ and N$_2$O from flaring associated with coal mining.
- **Oil and natural gas**: exploration, extraction, production, processing and transportation of natural gas and oil. Includes leakage, evaporation and storage losses, flaring and venting of CO$_2$, CH$_4$ and N$_2$O.

Industrial processes and product use

- **Mineral industry**: CO$_2$ from cement clinker and lime production; the use of limestone and dolomite and other carbonates in industrial smelting and other processes; soda ash production and use; and magnesia production.
- **Metal industry**: CO$_2$ and PFCs from aluminium smelting; CO$_2$, CH$_4$ and N$_2$O from iron and steel production; and CO$_2$ from the production of ferroalloys and other metals.
- **Chemical Industry**: includes N$_2$O from the production of nitric acid; CO$_2$ from ammonia production, acetylene use and the production of synthetic rutile and titanium dioxide; and CH$_4$ from polymers and other chemicals.
- **Other product manufacture and use**: CO$_2$ from the consumption of CO$_2$ in the food and drink industry and the use of sodium bicarbonate, SF$_6$ from electrical equipment.
- **Product uses as substitutes for Ozone Depleting Substances**: HFCs from refrigeration and air conditioning equipment, foam blowing, metered dose inhalers, fire extinguishers, solvent use.
- **Non-energy products from fuel and solvent use**: CO$_2$ produced by oxidation of lubricating oils and greases.

Agriculture

CH$_4$ and N$_2$O emissions from the consumption, decay or combustion of living and dead biomass, including:

- **Enteric fermentation in livestock**: emissions associated with microbial fermentation during digestion of feed by ruminant (mostly cattle and sheep) and some non-ruminant domestic livestock.
- **Manure management**: emissions associated with the decomposition of animal wastes while held in manure management systems.
- **Rice cultivation**: CH$_4$ emissions from anaerobic decay of organic material when rice fields are flooded.
- **Agricultural soils**: emissions associated with the application of fertilisers, crop residues and animal wastes to agricultural lands and the use of biological nitrogen fixing crops and pastures.
- **Field burning of agricultural residues**: emissions from field burning of cereal and other crop stubble, and the emissions from burning sugar cane prior to harvest.
- **Carbon dioxide emissions from the application of urea and lime**.
Waste

Emissions are predominantly CH₄. Small amounts of CO₂ and N₂O are generated through incineration and the decomposition of human wastes respectively. The main sources are:

- **Solid waste**: emissions resulting from anaerobic decomposition of organic matter in landfills.
- **Wastewater**: emissions resulting from anaerobic decomposition of organic matter in sewerage facilities (including on-site systems such as septic tanks) during treatment and disposal of wastewater.
- **Incineration**: emissions resulting from the incineration of solvents and clinical waste.
- **Biological treatment of solid waste**: emissions resulting from the anaerobic decomposition of organic material in composting and anaerobic digester facilities.

Land Use, Land Use Change and Forestry

The LULUCF sector includes:

- **Forest converted to other land uses**: emissions and removals resulting from the direct human-induced removal of forest and replacement with pasture, crops or other uses since 1972. Emissions arise from the burning and decay of cleared vegetation, and changes in soil carbon from current and past events.
- **Land converted to forest**: emissions and removals (i.e. sinks) from forests established on agricultural land. Growth of the forests and regrowth on cleared lands provides a carbon sink, while emissions can arise from soil disturbance on the cleared lands (N₂O). Both new plantings and the regeneration of forest from natural seed sources contribute to this classification as well as sequestration projects under the Emissions Reduction Fund.
- **Forest land remaining forest land**: emissions and removals in forests managed under a system of practices designed to support commercial timber production such as harvest or silvicultural practices or practices that are designed to implement specific sink enhancement activities. Forest harvesting causes emissions due to the decay of harvest slash and any subsequent prescribed burning. The regrowth of forests following harvesting provides a carbon sink and the harvested wood product pool can be a carbon sink or source depending on the rate of input and the rate of decay.
- **Wildfire emissions on forest land**: reported using IPCC guidance on natural disturbances. Further information on fire emissions occurring over the 2019-20 bushfire season is reported in the Australian Government’s National Inventory Report.
- **Cropland**: Anthropogenic emissions and removals on croplands occur as a result of changes in management practices on cropping lands, from changes in crop type (particularly woody crops) and from changes in land use.
- **Grazing land**: Anthropogenic emissions and removals on grasslands result from changes in management practices on grass lands, particularly from changes in pasture, grazing and fire management; changes in woody biomass elements and from changes in land use.
- **Wetlands**: Net emissions from the coastal lands including dredging of seagrass, aquaculture, and loss of tidal marsh areas. Changes in mangroves are reported under forest classifications.

5.13 Measurements

The units used in this quarterly update inventory are:
In this report, emissions are expressed in Mt CO$_2$-e, which represents millions of tonnes of carbon dioxide equivalent gas.

5.14 Science and innovation in the national greenhouse gas inventory

The Australian national greenhouse gas inventory meets international standards and has been reviewed by the UNFCCC on nineteen occasions and by the Australian National Audit Office twice. The most recent ANAO audit, conducted in 2017, found the inventory emissions calculations to be accurate to within 99.9%.

The inventory is prepared by a team of officials in the Department of Climate Change, Energy, the Environment and Water with extensive international experience. Many members of the team have participated in UN reviews of other countries’ data and five contributed to the most recent update of the IPCC Guidelines for the preparation of national greenhouse gas inventories. Inventory methods and data are reviewed before publication by the National Greenhouse Gas Inventory Committee, comprising representatives of the States and Territories under an agreement reached by the Council of Australian Governments in 1991.

The inventory estimates are based on the best available science. The inventory methods are supported by research and analysis through long term partnerships with the CSIRO Data61, CSIRO Land and Water, CSIRO Oceans and Atmosphere and the ANU and shorter term contributions from many academic institutions around Australia including UNSW, University of Sydney, Monash University, University of Queensland.

Timely emissions data has been released through the Quarterly Update of the National Inventory since 2010. Very few other governments provide such timely information (known updates are published by countries including the Netherlands, Sweden and New Zealand) with these updates usually being partial in coverage and focussed on the electricity or energy system only. In November 2021, Eurostat published a quarterly emissions account for the European Union for the first time. These quarterly accounts are now being published on a regular basis and include disaggregated emissions from EU member-states.

The Australian inventory systems have been built upon important innovations and early adoptions of emerging international techniques to measure, estimate and verify greenhouse gas emissions.
1. With the National Greenhouse and Energy Reporting Act 2007, the Australian parliament was among the first to legislate an integrated greenhouse gas emissions company reporting system, after the European Union in 2004, and the NGER scheme remains one of the most comprehensive integrated company reporting systems for greenhouse gas emissions anywhere.

2. Australian governments have invested in customised emissions data modelling software (AGEIS), which supports efficient production of high-quality data. Promotion of enhanced data monitoring and transparency internationally has been a long-standing objective of Australian Governments and the Australian approach to emissions data modelling and management has been used to assist the Thai Government to develop its own software (TGEIS) while information on software development has been shared with both the US Environment Protection Agency and the China Ministry of Ecology under a bilateral program managed by DFAT.

3. The Australian Government was the first to introduce the use of remote sensing techniques to detect forest loss and land clearing in national greenhouse gas inventories. Estimates of forest loss and land clearing for Australia, for each State and Territory and for some regions are updated and published every single year through this system. Australian Governments have championed the use of remote sensing techniques around the world and, in particular, have strongly supported the introduction of similar systems in Indonesia through bilateral partnerships managed by DFAT.

4. Net emissions from the land use, land use change and forestry sector are modelled through an integrated carbon stock model (FullCAM) which was originally supported through the commissioning of around 40 scientific reports and remains a leading example of integrated vegetation and soil carbon stock models around the world.

5. The use of ‘top-down’ inverse modelling techniques to test and raise the quality and robustness of emissions data, with a focus on methane and HFCs, has been introduced in the Australian inventory and this remains a rare example (along with Switzerland and the United Kingdom) of the use of these techniques in national greenhouse gas inventory systems. The Department is also exploring options for using new satellite datasets to complement other quality assurance work on National Greenhouse Accounts methane emission estimates.

6. The national inventory is produced as part of a set of National Greenhouse Accounts, which includes emissions data published at national, state and territory, and industry levels.

5.15 Future publications

The December 2022 Quarterly Update of Australia’s National Greenhouse Gas Inventory will be published by 31 May 2023.
5. Related publications and resources

Australia’s National Greenhouse Accounts

The following Department of Climate Change, Energy, the Environment and Water (DCCEEW) publications are all available at: https://www.dcceew.gov.au/climate-change/emissions-reporting/tracking-reporting-emissions

National Greenhouse Gas Inventory: Quarterly Updates

Quarterly Updates of Australia’s National Greenhouse Gas Inventory are the most up to date source of information on Australia’s national emissions. They provide a summary of Australia’s national emissions, updated on a quarterly basis. They give timely information to policy makers, markets and the public to demonstrate how Australia is tracking against its targets.


National Inventory Report 2020

The three volumes comprising Australia’s National Inventory Report 2020 were submitted under the UNFCCC and the Kyoto Protocol in May 2022. This report contains national greenhouse gas emission estimates for the period 1990-2020 and preliminary estimates for 2021 compiled under the rules for reporting applicable to the UNFCCC.

- Volume 1: Includes Australia’s data for energy (stationary energy, transport and fugitive emissions), industrial processes and product use, and agriculture.
- Volume 2: Australia’s data for the Land Use, Land Use Change and Forestry (LULUCF) and waste sectors, recalculation and improvements.
- Volume 3: Australia’s data for Kyoto Protocol LULUCF, Kyoto Protocol accounting requirements, annexes, glossary and references.


State and Territory Greenhouse Gas Inventories 2020

This document provides an overview of the latest available estimates of annual greenhouse gas emissions for Australia’s States and Territories. It complements Australia’s National Inventory Report 2020 and the National Inventory by Economic Sector 2020.

National Inventory by Economic Sector 2020


Australian Greenhouse Emissions Information System (AGEIS)

The AGEIS centralises the Department’s emissions estimation, emissions data management and reporting systems. AGEIS is being used to compile national and State and Territory inventories. The interactive web interface, known as the Australian National Greenhouse Accounts (ANGA), provides enhanced accessibility and transparency to Australia’s greenhouse emissions data: https://ageis.climatechange.gov.au/

Australia’s Emissions Projections 2022

The report provides detail on emissions trends, including sector specific analysis of factors driving emissions. The report estimates the emissions reduction effort required to meet Australia’s emissions reduction targets. The projections include sensitivity analyses to illustrate how emissions may differ under changes in economic growth.

Read the emissions projections reports: https://www.dcceew.gov.au/climate-change/emissions-reporting/projecting-emissions

Full Carbon Accounting Model

The Full Carbon Accounting Model (FullCAM) is the calculation engine which supports the estimation of carbon stock change on forest and agricultural systems. FullCAM can be downloaded from the Department’s webpage: https://www.dcceew.gov.au/climate-change/publications/full-carbon-accounting-model-fullcam

Australia’s Eighth National Communication/Fifth Biennial Report

Australia’s Eighth National Communication (2022) summarises information on Australia’s implementation of its UNFCCC and Kyoto Protocol obligations including: emissions and removals of greenhouse gases; national circumstances; policies and measures; vulnerability assessment; financial, technology and capacity building cooperation; education, training, and public awareness. Countries such as Australia are required to submit these reports to the UNFCCC every four years.
In accordance with international reporting requirements, the 2022 National Communication also incorporates Australia’s Fifth Biennial Report. Australia submitted its Fifth Biennial Report in 2022. These must be submitted every two years and outline Australia’s progress in achieving emission reductions and the provision of financial, technology, and capacity-building support. More information is available at:
https://unfccc.int/NC8

Australia’s first Annual Climate Change Statement

The Australian Government delivered the first Annual Climate Change Statement to Parliament in December 2022. In accordance with the Climate Change Act 2022, the Statement must be prepared annually and outline:
progress towards Australia’s emissions reduction targets; the economic, environmental and social impacts of climate change; the effectiveness of domestic policies to mitigate and adapt to climate change; international developments relevant to addressing climate change; and risks to Australia from climate change impacts. More information is available at:

What the rest of the world is doing

Other developed countries are also required to produce annual greenhouse gas inventories. More information regarding the reporting requirements and various international reports (including reports by Australia) are located online. https://unfccc.int/ghg-inventories-annex-i-parties/2021