Quarterly Update of Australia’s National Greenhouse Gas Inventory: September 2021

Incorporating emissions from the NEM up to December 2021

Australia’s National Greenhouse Accounts
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Preface

The *Quarterly Update* provides estimates of Australia’s national inventory of greenhouse gas emissions up to the September quarter of 2021, and preliminary estimates of emissions for the year-to-December quarter 2021.

Emissions for the year to September 2021 are estimated to be 501.5 Mt CO$_2$-e$^1$, down 0.8% or 4.0 Mt CO$_2$-e on the previous year. This decline in emissions reflects the balance of:

- Ongoing reductions in emissions from *electricity* (down 4.7%; 8.1 Mt CO$_2$-e);
- Lower *fugitive* emissions (down 5.1%; 2.6 Mt CO$_2$-e), resulting from declines in coal production;
- Increased *transport* emissions (up 1.4%; 1.3 Mt CO$_2$-e) reflecting a gradual recovery from the impacts of COVID restrictions on movement;
- Increased emissions from *stationary energy (excluding electricity)* (up 1.7%; 1.7 Mt CO$_2$-e) driven by an increase fuel combustion in the manufacturing sector; and
- Increased emissions from *agriculture* (up 3.8%; 2.8 Mt CO$_2$-e) due to the continuing recovery from recent drought.

Emissions in the year to September 2021 were 19.8% $^2$ below emissions for the year to June 2005 (the baseline year for Australia’s Paris target) (Figure P1).

*Figure P1: Emissions$^{3,4}$, by quarter, September 2000 to September 2021 (including preliminary December 2021)*

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1 Carbon dioxide equivalent (CO$_2$-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 5 - Technical Notes for further detail.

2 This estimate reflects the best available information at the time of publication. Further methodological improvements are being implemented for the next national inventory report. These improvements are anticipated to indicate a greater reduction in emissions on 2005 levels.

3 ‘Actual’, ‘seasonally adjusted, ‘weather normalised’ and ‘trend’ are defined in Section 5 - Technical notes

4 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.
On a quarterly basis, national emission levels for the September quarter 2021 decreased 0.5% or 0.6 Mt CO$_2$-e on the previous quarter in trend terms. The trend result for the September quarter 2021 reflects decreases across the electricity, and transport sectors. These decreases were partially offset by increases across the stationary energy, fugitive emissions, industrial processes and agriculture sectors.

In the year to September 2021, emissions per capita and the emissions intensity of the economy were at their lowest levels in 31 years. Emissions per capita were lower than 1990 by 47.1% while the emissions intensity of the economy was 67.0% lower than in 1990.

On an annual basis, the consumption-based inventory decreased 0.6% or 2.5 Mt CO$_2$-e to 418.5 Mt CO$_2$-e in the year to September 2021. Emissions associated with production of exports increased by 3.7% or 8.3 Mt CO$_2$-e to 230.8 Mt CO$_2$-e and emissions associated with consumption of imports increased by 7.1% or 9.8 Mt CO$_2$-e to 147.9 Mt CO$_2$-e.

National emissions are preliminarily estimated to be 501 Mt CO$_2$-e in the year to December 2021, an increase of 0.3% on the previous year. On a quarterly basis, national emissions are preliminarily estimated to be 124 Mt CO$_2$-e in trend terms, a decrease of 0.7% on the previous quarter.
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1. Overview

Table 1: National Greenhouse Gas Inventory\(^5\), September quarter 2021, rates of change

<table>
<thead>
<tr>
<th></th>
<th>September quarter 2021</th>
<th>Year to September 2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarterly change – seasonally adjusted and weather normalised(^6)</td>
<td>-1.7%</td>
<td></td>
</tr>
<tr>
<td>Quarterly change – seasonally adjusted and weather normalised – trend(^6)</td>
<td>-0.5%</td>
<td></td>
</tr>
<tr>
<td>Annual Change</td>
<td></td>
<td>-0.8%</td>
</tr>
</tbody>
</table>

Table 2: National Electricity Market (NEM)\(^7\), December quarter 2021, rates of change

<table>
<thead>
<tr>
<th></th>
<th>December quarter 2021</th>
<th>Year to December 2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarterly change – seasonally adjusted and weather normalised(^6)</td>
<td>-3.9%</td>
<td></td>
</tr>
<tr>
<td>Quarterly change – seasonally adjusted and weather normalised – trend(^6)</td>
<td>-2.1%</td>
<td></td>
</tr>
<tr>
<td>Annual Change</td>
<td></td>
<td>-5.3%</td>
</tr>
</tbody>
</table>

Summary of emissions in the September quarter 2021

National emissions for the September quarter 2021 decreased 0.5% or 0.6 Mt CO\(_2\)-e on the previous quarter in trend terms. Emissions were lower than the June 2021 quarter in the electricity and transport sectors in trend terms. These decreases were partially offset by increases in the stationary energy, fugitive emissions, industrial processes and agriculture sectors across the same period.

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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 5: Technical notes.

\(^7\) The NEM includes grid electricity in the Eastern and South Eastern states and accounts for approximately 81% of total electricity estimates in the year to September 2021.
Figure 1: Emissions\textsuperscript{8}, by quarter, September 2010 to September 2021

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1}
\caption{Emissions (Mt CO\textsubscript{2}-e), by quarter, September 2010 to September 2021}
\end{figure}

\textit{Source: Department of Industry, Science, Energy and Resources}

Figure 2: Change in emissions, by quarter, September 2010 to September 2021

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2}
\caption{Change in emissions (%), by quarter, September 2010 to September 2021}
\end{figure}

\textit{Source: Department of Industry, Science, Energy and Resources}

\textsuperscript{8} 'Seasonally adjusted', 'weather normalised', and 'trend' are defined in Section 5: Technical notes
Emissions of individual gases

Carbon dioxide (CO₂) emissions contribute the largest share of aggregate emissions in Australia at approximately 68% of total emissions. In trend terms, since the peak in September 2008, there has been a 26.3% or 30.8 Mt decline in quarterly emissions of carbon dioxide to 86.2 Mt in September 2021 (Figure 3). The most important factors causing this long term decline in CO₂ emissions include the continuing shift in the generation of electricity towards renewable fuel sources, and away from coal, and decreasing emissions in the Land sector. Against these downward forces, the long term growth of emissions from transport activity and the expansion of LNG exports have placed upward pressure on this time series.

Methane (CH₄) emissions contribute approximately 25% aggregate emissions in Australia. Overall CH₄ emissions have declined by 20.8% in trend terms since the peak in September 1990. Trends in CH₄ emissions are dominated by events in Agriculture such as drought, Fugitives related to coal, oil and gas production levels, and the Land and Waste sectors.

Nitrous oxide (N₂O) emissions contribute around 4% of aggregate emissions in Australia. Overall N₂O emissions have declined by 15.2% since the peak in September 2011. Trends in N₂O 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 (SF₆) 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 equipment.

Figure 3: Emissions, by quarter, by gas, trend, September 2000 to September 2021

Source: Department of Industry, Science, Energy and Resources
Summary of annual GHG emissions

Emissions for the year to September 2021 are estimated to be 501.5 Mt CO$_2$-e. The 0.8% or 4.0 Mt CO$_2$-e decrease in emissions over the year to September reflects annual decreases in emissions from the electricity and fugitives sectors. These decreases in emissions were partially offset by increases in emissions from the industrial processes, agriculture, stationary energy (excluding electricity), transport, land use, land use change and forestry and waste sectors (Table 3).

Table 3: Actual annual emissions, by sector, for the year to September 2020 and 2021

<table>
<thead>
<tr>
<th>Sector</th>
<th>Annual emissions (Mt CO$_2$-e) year to September 2020</th>
<th>Annual emissions (Mt CO$_2$-e) year to September 2021</th>
<th>Change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy – Electricity</td>
<td>170.4</td>
<td>162.3</td>
<td>-4.7%</td>
</tr>
<tr>
<td>Energy – Stationary energy excluding electricity</td>
<td>99.4</td>
<td>101.1</td>
<td>1.7%</td>
</tr>
<tr>
<td>Energy – Transport</td>
<td>89.7</td>
<td>90.9</td>
<td>1.4%</td>
</tr>
<tr>
<td>Energy – Fugitive emissions</td>
<td>51.7</td>
<td>49.1</td>
<td>-5.1%</td>
</tr>
<tr>
<td>Industrial processes and product use</td>
<td>31.9</td>
<td>32.5</td>
<td>1.9%</td>
</tr>
<tr>
<td>Agriculture</td>
<td>73.3</td>
<td>76.1</td>
<td>3.8%</td>
</tr>
<tr>
<td>Waste</td>
<td>13.7</td>
<td>13.9</td>
<td>1.6%</td>
</tr>
<tr>
<td>Land Use, Land Use Change and Forestry</td>
<td>-24.6</td>
<td>-24.4</td>
<td>0.5%</td>
</tr>
<tr>
<td>National Inventory Total</td>
<td>505.5</td>
<td>501.5</td>
<td>-0.8%</td>
</tr>
</tbody>
</table>

Figure 4: Share of total emissions, by sector, for the year to September 2021

Source: Department of Industry, Science, Energy and Resources
Over the year to September 2021 the 4.7% decrease in emissions from the electricity sector reflected a decrease of 4.2% in coal generation and an increase of 17.2% in supply from renewable sources in the NEM.

Transport emissions increased 1.4% over the year to September 2021. Petrol consumption increased 1.5% while consumption of domestic jet fuel was lower by 7.9% on the year to September 2020.

Emissions from the agriculture sector increased 3.8% to 76.1 Mt CO$_2$-e, reflecting a continuation of recent improvements in conditions in the sector.

Emissions in Australia from export industries increased 4.4% (8.5 Mt CO$_2$-e).

In the year to December 2021, the preliminary estimate for total emissions is 501 Mt CO$_2$-e. This would be a decline of 0.3% or 1.5 Mt CO$_2$-e on the year to December 2020. This estimate will be finalised with the publication of the December 2021 Quarterly Update in May 2022.

**Long term sectoral trends**

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

- *Electricity* – where emissions have fallen by 23.3% since the year to June 2009 as renewables have displaced coal as a fuel source, reversing the long term increases experienced in earlier years;

- *Stationary energy (excluding electricity)* – which has shown the largest growth of any sector in percentage terms since 1990. Emissions have increased 52.2% or 34.7 Mt CO$_2$-e driven, in particular, by recent growth in the export of LNG;

- *Transport* – where emissions have increased 48.8% or 29.8 Mt CO$_2$-e since 1990, despite recent volatility due to the impacts of the COVID pandemic;

- *Fugitives* – where emissions have increased 22.3% or 8.9 Mt CO$_2$-e since 1990. Emissions were relatively stable until 2012 but have increased strongly as a result of the growth of the LNG industry;

- *Agriculture* – where emissions have declined by 17.2% or 15.8 Mt CO$_2$-e since 1990, in line with declining cattle and sheep populations; and,

- *Land Use, Land Use Change and Forestry (LULUCF)* – where emissions have decreased by the largest margin of any sector since 1990 (112.9% or 214.3 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.

The changes in emissions from each sector from the year to September 1990 to 2021 in percentage terms are presented in Figure 5.
2. Sectoral Analysis

2.1. Energy – Electricity

*Electricity* generation is the largest source of emissions in the national inventory, accounting for 32.4% of emissions in the year to September 2021 (Figure 4).

*Electricity* sector emissions are experiencing a long term decline, down 23.3% (49.3 Mt CO$_2$-e) from the peak recorded in the year to June 2009 (Data Table 1A).

Electricity sector emissions decreased 1.3% in the September quarter of 2021 on a trend basis (Figure 6). This reflected a 3.9% increase in renewable generation in the NEM. The September quarter 2021 saw metered demand in the NEM higher by 0.9% than in the previous quarter.

Over the course of the year to September 2021, emissions from *electricity* decreased 4.7% compared with the year to September 2020, due to the ongoing substitution of renewable energy for fossil fuel power sources.
National Electricity Market (NEM) emissions

Emissions in the NEM for the December quarter 2021 decreased 2.1% on a trend basis compared with the previous quarter (Figure 7).
For the December 2021 quarter, generation from renewables increased 3.9% in trend terms (Figure 8).

**Figure 8: Cumulative change in electricity generation in the NEM, trend, by fuel, by quarter, December 2010 to December 2021**

![Electricity Generation](image)


### 2.2. Energy – Stationary energy excluding electricity

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

In the year to September 2021, **stationary energy excluding electricity** accounted for 20.2% of Australia’s national inventory (Figure 4).

Emissions from **stationary energy excluding electricity** in the September quarter of 2021 increased 0.8% (0.2 Mt CO₂-e) in trend terms compared with the previous quarter. Emissions over the year to September 2021 increased 1.7% when compared with the previous year (Figure 9).

An important driver of emissions trends in stationary combustion over the last 5 years has been the production of LNG for export. Figure 10 shows that LNG production has increased by 199% compared to the year to September 2015, before the start of the rapid ramp up.
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 2021, transport accounted for 18.1% of Australia’s national inventory (Figure 4).

Emissions in the September 2021 quarter decreased 3.6% in trend terms on the previous quarter, reflecting the impact of restrictions on movement imposed in the second half of 2021 (Figure 11). Despite emissions in the previous quarter reflecting a return towards normal levels of transport activity, the return of widespread lockdowns in the September quarter 2021 resulted in decreases in emissions from the transport sector.

Emissions from transport over the year to September 2021 increased 1.4% compared with the previous year, notwithstanding the sharp decrease in the September quarter 2021. This increase was partly the result of a 4.3% increase in diesel consumption (noting that unlike petrol and aviation fuel, diesel consumption did not experience significant drops due to strong demand for freight services during COVID related movement restrictions) and a 1.5% increase in petrol consumption (Figure 12).

Figure 11: Transport emissions, actual and trend, by quarter, September 2010 to September 2021

Source: Department of Industry, Science, Energy and Resources
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 1.5% in trend terms.

LNG production was higher by 14.8% in the September 2021 quarter, as technical and maintenance issues that impacted production in the June quarter were resolved. Carbon dioxide injection at the Gorgon project remained below maximum capacity but averaged 330 kt CO$_2$ over the quarter (around 2.2 Mt CO$_2$ for the year to June 2021)$^9$. Coal production was lower by 1.2% in the September 2021 quarter.

Annual emissions in this sector decreased 5.1% over the year to September 2021 (Figure 13). This was driven by an overall decrease in coal production of 3.8% over the year.

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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 2021, *industrial processes and product use* accounted for 6.5% of Australia’s national inventory (Figure 4). Emissions increased 1.9% (0.6 Mt CO₂-e) in actual terms over the year to September 2021 (major subcategories are shown in Figure 14).

Emissions from *industrial processes and product use* were materially unchanged in the September quarter in trend terms.
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. Carbon dioxide emissions are reported from the application of urea and lime.

In the year to September 2021, agriculture accounted for 15.2% of Australia’s national inventory (Figure 4). Emissions from agriculture increased 3.8% (2.8 Mt CO$_2$-e) in actual terms over the year to September 2021 (Figure 15).
Drought conditions have continued to ease in the September quarter 2021. More favourable seasonal conditions have led to herd and flock rebuilding, however livestock population numbers are yet to fully recover\textsuperscript{10}. There has been some rebound in crop production, particularly rice, in the September quarter 2021 due to more favourable climatic conditions. Emissions from production of many crops is likely to stabilise in future quarters, but rice and cotton production are forecast to increase further\textsuperscript{11}.

### 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 2021, waste accounted for 2.8% of Australia’s national inventory (Figure 4).

Emissions from waste increased 1.6% (0.2 Mt CO$_2$-e) over the year to September 2021 due to decreased gas capture at solid waste disposal sites (Figure 16).


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 2021, the LULUCF sector Accounted for -4.9% of Australia’s national inventory – a net sink (Figure 4).

Net emissions for the LULUCF sector in the year to September 2021 are estimated to be -24.4 Mt CO₂-e (Figure 17). The magnitude of this net sink has decreased by 0.5% (0.1 Mt CO₂-e) on the previous twelve months due to an increase in emissions from agricultural soils, partially offset by a continuing decline in land clearing emissions (Figure 17).

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12 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.
3. Emissions per capita and per dollar of GDP

In the year to September 2021, emissions per capita and the emissions intensity of the economy are at their lowest levels in 31 years\(^{13}\).

National inventory emissions per capita were 19.5 t CO\(_2\)-e per person in the year to September 2021. This represents a 47.1\% decline from 36.9 t CO\(_2\)-e per person in the year to September 1990.

Over the period from September 1990 to September 2021, Australia’s population grew strongly from 17.1 million to around 25.7 million, an increase of 50.3\%\(^{14,15}\).

Australia’s real GDP (chain volume measures) also experienced significant growth over this period, expanding from \$0.8 trillion in the year to September 1990 to around \$2.0 trillion in the year to September 2021, an increase of 142.0\%\(^{16}\).

National inventory emissions per dollar of real GDP fell from 0.8 kg CO\(_2\)-e per dollar in the year to September 1990 to 0.2 kg CO\(_2\)-e per dollar in the year to September 2021 (Figure 18). This represents a decline of 67.0\% from the year to September 1990.

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\(^{13}\) 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).


Figure 18: Emissions per capita and per dollar of real GDP, actual year to September 1990 to 2021

Source: Department of Industry, Science, Energy and Resources
4. Consumption-based national greenhouse gas inventory

Table 4: Consumption-based national greenhouse gas inventory\textsuperscript{17}, September quarter and year to September 2021, emissions growth rates

<table>
<thead>
<tr>
<th></th>
<th>September quarter 2021</th>
<th>Year to September 2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarterly change – seasonally adjusted\textsuperscript{18}</td>
<td>-4.4%</td>
<td></td>
</tr>
<tr>
<td>Quarterly change – seasonally adjusted– trend</td>
<td>-0.2%</td>
<td></td>
</tr>
<tr>
<td>Annual Change</td>
<td></td>
<td>-0.6%</td>
</tr>
</tbody>
</table>

A consumption based emissions projection accounts only for emissions generated, either domestically or overseas, in support of production of goods and services that are finally consumed in Australia. This accounting approach excludes emissions generated during the production of exports, but also includes overseas emissions generated during production of the products that are imported for domestic consumption.

On an annual basis, the consumption-based inventory decreased 0.6% or 2.5 Mt CO\textsubscript{2}-e to 418.5 Mt CO\textsubscript{2}-e in the year to September 2021.

Emissions in Australia associated with production of exports increased by 8.3 Mt CO\textsubscript{2}-e (up 3.7%) and emissions associated with consumption of imports increased by 9.8 Mt CO\textsubscript{2}-e (up 7.1%).

Emissions in the national greenhouse gas inventory associated with the production of goods for export are not included in the consumption-based inventory. The national greenhouse gas inventory is increasingly driven by producing goods for exports. After deducting these emissions, national greenhouse gas inventory emissions that are associated with domestic consumption declined by 12.5 Mt CO\textsubscript{2}-e (4.0 %).

Emissions generated by Australian consumption were 143.9 Mt CO\textsubscript{2}-e (25.6%) lower compared to the year 2005, and were less than the (production-based) national greenhouse gas inventory by 82.9 Mt CO\textsubscript{2}-e or 16.5% in the year to September 2021 (Figure 19).

On a trend basis, Australia’s consumption-based inventory was lower relative to the previous quarter (0.3 Mt CO\textsubscript{2}-e or 0.2%).

Consumption-based emissions are approximately 16.3 tonnes per person per year, which is around 3 tonnes per person less than the per capita emission level using the national greenhouse gas inventory.

\textsuperscript{17} National emissions levels are inclusive of all sectors of the economy, including Land Use, Land Use Change and Forestry (LULUCF).

\textsuperscript{18} ‘Actual’, ‘seasonally adjusted and ‘trend’ are defined in Section 5: Technical notes.
Figure 19: National Greenhouse Gas and Consumption-based inventories, Australia, by quarter, September 2005 to September 2021

Source: Department of Industry, Science, Energy and Resources

Figure 20: Global emissions generated during production of Australia’s imports and exports, by quarter, September 1990 to September 2021

Source: Department of Industry, Science, Energy and Resources
Special Topic 1 – New satellite data driving National Greenhouse Accounts improvements

New spatial data on methane concentrations in air columns below the orbiting European Space Agency satellite Sentinel 5p have been used by some researchers to make ‘top-down’ estimates of methane fluxes across Australia and around the world. Some of these analyses have been targeted at particular point sources of methane emissions (like in the Bowen Basin) (Sadavarte et al 2021) and some have been global in nature and which, therefore, incidentally include estimates for Australia (Deng et al 2021).

The Department believes that the new satellite data is valuable and opens up new possibilities to test and improve the emission estimates reported in national greenhouse gas inventories. Like the Intergovernmental Panel on Climate Change (IPCC), however, the Department considers it premature to use such data sources to directly attempt to estimate emissions for use in the inventory. The March 2021 edition of the Quarterly Update detailed the Department’s views on why making reliable, ‘top-down’ estimates of emissions from satellite data on methane mixing ratios is highly challenging.

The Department keeps emission estimation methods under review as part of its commitment to continuous improvement of the national greenhouse gas inventory. While it remains cautious about the risks of over-interpretation of the data provided by the researchers, the emergence of the satellite datasets has catalysed a departmental review of inventory methods for open-cut coal mines in Queensland (QLD). The review has resulted in an average annual 44% increase of 1.6 Mt CO₂-e in methane emission estimates from QLD open-cut coal mines, which translates into a 0.3% average annual increase in total national emissions across the time-series between 1990 and 2021. This Special Topic details the method improvements that formed the basis for those results.

Further refinements to this and other methane emissions estimation methods are planned. The Department will also continue to explore options for using the new satellite datasets to complement other quality assurance work on National Greenhouse Accounts methane emission estimates.

Fugitive emissions from Queensland open-cut coal mines – method improvement

The emergence of the satellite data prompted the Department to review its existing methods for the estimation of methane emissions from QLD open cut coal mines.

The estimation of methane emissions from underground coal mines is considered reliable coming, as it does, from monitors located in mine shafts operating under State Government OH&S requirements and reported to the Clean Energy Regulator under the National Greenhouse and Energy Reporting Act 2007. The method for open-cut coal mines however relies on data on the size of the coal operations and emission factors derived from Commonwealth Scientific and Industrial

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19 “Use of satellite observations in inverse modelling for anthropogenic emission estimates is still in the experimental stage, due to multiple technical challenges of producing the high-quality concentration retrievals from the satellite-observed spectra” (IPCC 2019)

20 Quarterly Update of Australia’s National Greenhouse Gas Inventory: March 2021, Australian Government Department of Industry, Science, Energy and Resources:
Research Organisation (CSIRO) research. These emissions factors were derived from a 1993 study which measured methane fluxes in a small number of locations in the Bowen Basin.

The improved method is based on data on the methane content in coal seams in the Bowen and Surat Basins, derived from the QLD Government Petroleum Exploration Dataset (the Petroleum dataset). The Petroleum dataset includes geological data sourced from drilling of petroleum wells, coal seam gas wells (CSG), stratigraphic bores, coal and mineral drillholes. Measurements from the Petroleum dataset provide an estimate of methane in the coal seams waiting for release (a ‘bottom-up’ estimate of methane emissions from open-cut coal mines), with the new method presuming that all gas contained within the coal seam will be released upon the coal’s extraction.

The Petroleum dataset was processed to exclude gas content data outside active coal mine fields and aggregate the drillhole observations into 50m depth classes by average and median values. The results of the pre-processing demonstrated a strong, linear relationship between the methane content of the strata and the depth class the measurement was taken at.

*Figure ST1 Methane content by depth of measurement*

The average values in Figure ST1 are higher than the median due to the presence of outlier observations in wells/drill holes with significantly higher gas contents. These outlier observations were retained as it is not uncommon within the fugitive emissions category for a small amount of locations to emit a higher proportion of total emissions.
A desk top analysis of coal mining environmental and planning documents was conducted to determine common operating depths of QLD open cut coal mines and expert judgement was applied to determine what proportion of mining activity occurred within a specific 50m depth class. This analysis was then used to derive the emissions factor using the average methane content values in Figure ST1, as set out in Table ST1.

**Table ST1 Comparison of previous and improved CH₄ emission factors for open cut coal mines**

<table>
<thead>
<tr>
<th>Emissions factor (CH₄ m³/tonne of coal prod)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved method</td>
</tr>
<tr>
<td>Previous method</td>
</tr>
</tbody>
</table>

The result of the improved method is an increase in emissions across the time series (Figure ST2). The average annual increase in fugitive emissions for QLD open cut coal mines is 1.6 Mt CO₂-e. The method improvement increases annual emissions from the fugitive emissions from fuels and total inventory by an average of 3.6% and 0.3% respectively (1.6 Mt CO₂-e) across the time-series between 1990 and 2021.

**Figure ST2 Fugitive emissions estimates for QLD open cut coal mines**

These revisions represent a significant improvement in the method for estimating emissions from QLD open cut mines. The Petroleum dataset underpinning the revised emissions factor has greater geographic coverage and a much larger number of observations than the original CSIRO study, decreasing uncertainty and the influence of natural variability.

This method was implemented from the June 2021 Quarterly Update and will be included in future updates to Australia’s inventory. Further refinements to this new emissions estimation method will be possible in future. The Department will continue to investigate options for determining mining depth of individual mines to enable the development of facility-specific emissions factors which takes into account that facility’s mining practices. The Department will also investigate opportunities
to apply the improved QLD method to other jurisdictions, where sufficient geological data is available.

References


5. Technical notes

5.1. Quarterly Coverage

The Quarterly Update uses emissions estimates based on our United Nations Framework Convention on Climate Change (UNFCCC) inventory time series to better support implementation of Australia’s 2030 and 2050 targets. This UNFCCC inventory will be used to track progress towards Australia’s commitment under the Paris Agreement to reduce emissions 26 to 28% below 2005 levels by 2030 and achieve net zero emissions by 2050.

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 the Biden Administration and ensures Australia’s accounting is complete.

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 Intergovernmental Panel on Climate Change (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 the Government’s Nationally Determined Contribution (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 Secretariat each year between 15 April and 27 May. 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 carbon dioxide equivalent (CO₂-e) basis using the Global Warming Potential (GWP) weighting factors indicated in Table 5. As greenhouse gases vary in their radiative activity and in their atmospheric residence time, converting emissions into CO₂-e allows the integrated effect of emissions of the various gases to be compared.

Commencing with the Quarterly Update of December 2020, the Department has applied the 100-year time GWP values from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) to estimate emissions, consistent with rules adopted under the UN Framework Convention on Climate Change (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 Nationally Determined Contribution of 26-28% below 2005 levels by 2030, on an emissions budget basis.

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
Quarterly Update of Australia’s National Greenhouse Gas Inventory: September 2021

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

Table 5: 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 (CO$_2$)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Methane (CH$_4$)</td>
<td>25</td>
<td>28</td>
</tr>
<tr>
<td>Nitrous oxide (N$_2$O)</td>
<td>298</td>
<td>265</td>
</tr>
<tr>
<td>Perfluorocarbon - CF4</td>
<td>7,390</td>
<td>6,630</td>
</tr>
<tr>
<td>Perfluorocarbon – C2F6</td>
<td>12,200</td>
<td>11,100</td>
</tr>
<tr>
<td>HFC-23</td>
<td>14,800</td>
<td>12,400</td>
</tr>
<tr>
<td>HFC-32</td>
<td>675</td>
<td>677</td>
</tr>
<tr>
<td>HFC-41</td>
<td>92</td>
<td>116</td>
</tr>
<tr>
<td>HFC-43-10mee</td>
<td>1,640</td>
<td>1,650</td>
</tr>
<tr>
<td>HFC-125</td>
<td>3,500</td>
<td>3,170</td>
</tr>
<tr>
<td>HFC-134</td>
<td>1,100</td>
<td>1,120</td>
</tr>
<tr>
<td>HFC-134a</td>
<td>1,430</td>
<td>1,300</td>
</tr>
<tr>
<td>HFC-143</td>
<td>353</td>
<td>328</td>
</tr>
<tr>
<td>HFC-143a</td>
<td>4,470</td>
<td>4,800</td>
</tr>
<tr>
<td>HFC-152</td>
<td>53</td>
<td>16</td>
</tr>
<tr>
<td>HFC-152a</td>
<td>124</td>
<td>138</td>
</tr>
<tr>
<td>HFC-161</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>HFC-227ea</td>
<td>3,220</td>
<td>3,350</td>
</tr>
<tr>
<td>HFC-236cb</td>
<td>1,340</td>
<td>1,210</td>
</tr>
<tr>
<td>HFC-236ea</td>
<td>1,370</td>
<td>1,330</td>
</tr>
<tr>
<td>HFC-236fa</td>
<td>9,810</td>
<td>8,060</td>
</tr>
<tr>
<td>HFC-245ca</td>
<td>693</td>
<td>716</td>
</tr>
<tr>
<td>HFC-245fa</td>
<td>1,030</td>
<td>858</td>
</tr>
<tr>
<td>HFC-365mfc</td>
<td>794</td>
<td>804</td>
</tr>
<tr>
<td>Sulphur hexafluoride (SF$_6$)</td>
<td>22,800</td>
<td>23,500</td>
</tr>
</tbody>
</table>

Australia’s emissions of the greenhouse gas nitrogen trifluoride (NF$_3$) 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 consistently with international guidelines, are estimated on a time series consistent basis and are subject to annual international expert review.

Recalculations since the June Quarter 2021

The recalculations since the June 2021 edition of the Quarterly Update for the financial years 2005 and 2019 to 2021, by sector in Mt CO₂-e, are shown in Table 6 and are a result of the incorporation of updated emission factors and methodologies used to calculate annual inventory estimates.

Recalculations in this Quarterly Update also include updates to indicators used to derive emissions estimates in the quarters beyond the latest official 2018-19 inventory year reported in the Australian Government’s annual National Inventory Report submitted under the UNFCCC.
Table 6: Recalculations (Mt CO2-e) since the June 2021 Quarterly Update, by sector, 2005 and 2019 to 2021

<table>
<thead>
<tr>
<th>Sector</th>
<th>Financial Years and Quarters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2005</td>
</tr>
<tr>
<td></td>
<td>Sep</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0.0</td>
</tr>
<tr>
<td>Electricity</td>
<td>0.0</td>
</tr>
<tr>
<td>Stationary energy (excluding electricity)</td>
<td>-0.2</td>
</tr>
<tr>
<td>Transport</td>
<td>0.0</td>
</tr>
<tr>
<td>Fugitive emissions</td>
<td>0.1</td>
</tr>
<tr>
<td>Industrial processes and product use</td>
<td>-0.3</td>
</tr>
<tr>
<td>Waste</td>
<td>0.0</td>
</tr>
<tr>
<td>LULUCF</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>-0.4</td>
</tr>
</tbody>
</table>

5.6. Source Data

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

- Australian Bureau of Statistics (2022), Australian Demographic Statistics, pub. no. 3101

- Australian Bureau of Statistics (2022), Population Clock.


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.

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
Quarterly Update of Australia’s National Greenhouse Gas Inventory: September 2021

5.11. Quarterly uncertainty

For all sectors the Department’s assessment is that the 90% confidence interval for the national inventory is ± 4.2% (i.e. there is a 90% probability that future revisions will be limited to ± 4.2% of the current estimate).

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**: CO₂ and CH₄ from coal mining activities, post-mining and decommissioned mines and CO₂, CH₄ and N₂O 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 CO₂, CH₄ and N₂O.

Industrial processes and product use

- **Mineral industry:** CO₂ 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:** CO₂ and PFCs from aluminium smelting; CO₂, CH₄ and N₂O from iron and steel production; and CO₂ from the production of ferroalloys and other metals.
- **Chemical Industry:** includes N₂O from the production of nitric acid; CO₂ from ammonia production, acetylene use and the production of synthetic rutile and titanium dioxide; and CH₄ from polymers and other chemicals.
- **Other product manufacture and use:** CO₂ from the consumption of CO₂ in the food and drink industry and the use of sodium bicarbonate, SF₆ 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:** CO₂ produced by oxidation of lubricating oils and greases.

Agriculture

CH₄ and N₂O 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:** CH₄ 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 Emission 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:

- grams (g)
- tonnes (t)
- metres (m)
- litres (L)

Standard metric prefixes used in this inventory are:

- kilo (k) = 10³ (thousand)
- mega (M) = 10⁶ (million)
- giga (G) = 10⁹
- tera (T) = 10¹²
- peta (P) = 10¹⁵
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 fifteen 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 Industry, Science, Energy and Resources with extensive international experience. Eight 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. It is understood that these updates will be published regularly.

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 system 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 (Switzerland and the United Kingdom are examples of others) of the use of these techniques in national greenhouse gas inventory systems.

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 as well as on a consumption-basis (see section 4.)

### 5.15. Future publications

The December 2021 Quarterly Update of Australia’s National Greenhouse Gas Inventory will be published by 31 May 2022.
Tracking Australia’s emissions

The data presented in Table 7 and Figure 21 include Australia’s annual emissions for 2000 to 2021.

Australia’s annual emissions for the year to September 2021 are estimated to be 501.5 Mt CO$_2$-e. This figure is 10.1% below emissions in the year to September 2000 (557.6 Mt CO$_2$-e) and 19.8% below emissions in the year to September 2005 (625.1 Mt CO$_2$-e).

Table 7: National inventory total from 2000 to 2020, by financial year and year to September 2021

<table>
<thead>
<tr>
<th>Financial Year</th>
<th>Emissions (Mt CO$_2$-e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>557.6</td>
</tr>
<tr>
<td>2001</td>
<td>588.1</td>
</tr>
<tr>
<td>2002</td>
<td>581.7</td>
</tr>
<tr>
<td>2003</td>
<td>593.1</td>
</tr>
<tr>
<td>2004</td>
<td>595.2</td>
</tr>
<tr>
<td>2005</td>
<td>625.1</td>
</tr>
<tr>
<td>2006</td>
<td>626.3</td>
</tr>
<tr>
<td>2007</td>
<td>646.4</td>
</tr>
<tr>
<td>2008</td>
<td>632.0</td>
</tr>
<tr>
<td>2009</td>
<td>631.9</td>
</tr>
<tr>
<td>2010</td>
<td>613.4</td>
</tr>
<tr>
<td>2011</td>
<td>585.9</td>
</tr>
<tr>
<td>2012</td>
<td>574.4</td>
</tr>
<tr>
<td>2013</td>
<td>561.1</td>
</tr>
<tr>
<td>2014</td>
<td>549.3</td>
</tr>
<tr>
<td>2015</td>
<td>547.0</td>
</tr>
<tr>
<td>2016</td>
<td>532.0</td>
</tr>
<tr>
<td>2017</td>
<td>528.6</td>
</tr>
<tr>
<td>2018</td>
<td>541.2</td>
</tr>
<tr>
<td>2019</td>
<td>530.6</td>
</tr>
<tr>
<td>2020</td>
<td>512.5</td>
</tr>
<tr>
<td>2021*</td>
<td>501.5</td>
</tr>
</tbody>
</table>

* Year to September

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21 This estimate reflects the best available information at the time of publication. Further methodological improvements are being implemented for the next national inventory report. These improvements are anticipated to indicate a greater reduction in emissions on 2005 levels.

22 2021 – covers year to September
Figure 21: National inventory total, from 2000 to 2021\textsuperscript{23}, by financial year and year to September 2021

\begin{center}
\begin{tikzpicture}
\begin{axis}[
    width=\textwidth,
    height=0.4\textwidth,
    scale only axis,
    xmin=2000, xmax=2022,
    ymin=400, ymax=700,
    ytick={400,450,500,550,600,650,700},
    xticklabels={
    xlabel=Year,
    ylabel=Emissions (Mt CO\textsubscript{2}-e),
    legend pos=north west,
]
\addplot[blue,smooth] table[ header=false, x index=0, y index=1 ]{data.csv};
\end{axis}
\end{tikzpicture}
\end{center}

Source: Department of Industry, Science, Energy and Resources

\textsuperscript{23} 2021 covers year to September.
6. Related publications and resources

Australia’s national Greenhouse Accounts

The following Department of Industry Science Energy and Resources (DISER) publications are all available at: https://www.industry.gov.au/policies-and-initiatives/australias-climate-change-strategies/tracking-and-reporting-greenhouse-gas-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 2019

The three volumes comprising Australia’s National Inventory Report 2019 were submitted under the UNFCCC and the Kyoto Protocol in April 2021. This report contains national greenhouse gas emission estimates for the period 1990-2019 and preliminary estimates for 2020 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, recalculations 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 2019

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 2019 and the National Inventory by Economic Sector 2019.

National Inventory by Economic Sector 2019


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 provides enhanced accessibility and transparency to Australia’s greenhouse emissions data: [https://ageis.climatechange.gov.au/](https://ageis.climatechange.gov.au/)

Australia’s Emissions Projections 2021


Full Carbon Accounting Model


Australia’s Seventh National Communication/Fourth Biennial Report

Australia’s Seventh National Communication (2017) 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 2017 National Communication also incorporates Australia’s Third Biennial Report. Australia has recently submitted its Fourth Biennial Report (2019). 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:
http://unfccc.int/national_reports/annex_i_natcom/submitted_natcom/items/10138.php

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