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NSW greenhouse gas emissions projections 2023

Methods paper

Department of Climate Change,
Energy, the Environment and Water

NSW GOVERNMENT

Acknowledgement of Country

Department of Climate Change, Energy, the Environment and Water acknowledges the Traditional Custodians of the lands where we work and live.

We pay our respects to Elders past, present and emerging.

This resource may contain images or names of deceased persons in photographs or historical content.

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Summary

The *Climate Change (Net Zero Future) Act 2023* legislates the NSW Government's ambitious approach to addressing climate change. It enshrines whole-of-government climate action to deliver net zero by 2050 and legislates NSW's greenhouse gas (GHG) emissions reduction targets of:

- 50% reduction on 2005 levels by 2030
- 70% reduction on 2005 levels by 2035
- net zero by 2050.

The NSW Department of Climate Change, Energy, the Environment and Water (the department) has projected future trends in GHG emissions to monitor progress towards achieving NSW's legislated targets. This methods paper summarises the emissions trends and describes the assumptions and methodologies applied in preparing the projections.

Emissions projections are updated annually using the latest available activity data, peer-reviewed methods and expert assumptions. Emissions are modelled for each year out to 2050 and by Intergovernmental Panel on Climate Change (IPCC) category, using sectors and subsectors consistent with the NSW Greenhouse Gas Inventory and national emissions projections. Emission projections represent 'scenario modelling' and are the best estimate of a future scenario under the various assumptions applied at a point in time.

Emissions projections are developed for a business as usual (BAU) scenario and 2 current policy scenarios. The BAU scenario accounts for major factors impacting NSW emissions, including market trends, but excludes the impact of the *Net Zero Plan Stage 1: 2020–2030* (DPIE 2020; referred to as the Net Zero Plan) and related policies. The current policy scenarios are developed based on the BAU scenario, but they account for emissions reductions projected to be achieved by the Net Zero Plan and related policies. In other words, the current policy projections are effectively the BAU emissions with the addition of emissions reduction under the Net Zero Plan and related policies. The BAU emissions trajectory therefore informs the level of additional effort required to progress towards achieving NSW's net zero objectives.

Both the BAU and the current policy scenarios are updated each year. For example, the BAU scenario is updated to account for the latest population estimates, the latest commodity and production forecasts, and evolving understanding of post-COVID recovery. The current policy scenario is updated to account for changes to existing programs and policies, revised abatement projections and new policy announcements.

The current policy is defined to include Net Zero Plan programs plus related policies, as follows:

- current actions under stage 1 of the Net Zero Plan, including strategies, plans and programs

- related policies, such as the NSW Environment Protection Authority's *EPA Climate Change Policy* (EPA 2023a) and *EPA Climate Change Action Plan 2023–26* (EPA 2023b (referred to collectively as EPA climate change policy and action plan or CCPAP), and Australian Government's Safeguard Mechanism reforms (Cth DCCEEW 2023a)
- future initiatives related to reducing emissions supported by the NSW Climate Change Fund (established under Part 6A of the *Energy and Utilities Administration Act 1987*) under stages 2 and 3 of the Net Zero Plan over 2030–2050.

Two abatement scenarios are presented for the current policy, as follows:

- program/policy 'abatement as originally designed'
- program/policy 'abatement as currently tracking'.

The difference between these scenarios is described further in subsequent sections.

Under the abatement as originally designed scenario, New South Wales remains on track to achieve its targets, reaching 50% below 2005 levels in 2030 and 70% below 2005 levels in 2035. However, when uncertainty in some programs/policies is considered, a more cautious outlook under the abatement as currently tracking scenario indicates more work may be needed. Accounting for abatement uncertainty, New South Wales is projected to be 44% to 50% below 2005 levels by 2030 and 65% to 70% by 2035.

Further discussion on assumptions and the projection results are provided in the following sections. Data is accessible via the interactive NSW Net Zero Emissions Dashboard and as data downloads from the NSW Sharing and Enabling Environmental Data (SEED) portal (NSW Government 2022a).

Introduction

The *Climate Change (Net Zero Future) Act 2023* legislates the NSW Government's ambitious approach to addressing climate change. It enshrines whole-of-government climate action to deliver net zero by 2050 and legislates NSW's greenhouse gas (GHG) emissions reduction targets of:

- 50% reduction on 2005 levels by 2030
- 70% reduction on 2005 levels by 2035
- net zero by 2050.

The *Net Zero Plan Stage 1: 2020–2030* (DPIE 2020; referred to as the Net Zero Plan), released in March 2020, is the NSW Government's plan to achieve emissions reduction by 2030 and prepare the state for further action in the decades to follow. The plan outlines how the government will grow the economy, create jobs and reduce the cost of living through strategic emissions reduction initiatives across the economy. The plan delivers on the objectives of the *NSW Climate change policy framework* (OEH 2016), which sets out long-term policy directions for action to mitigate and adapt to climate change.

The NSW Government monitors and reports on progress towards achieving our legislated net zero targets. The NSW Department of Climate Change, Energy, the Environment and Water (the department) is responsible for:

- delivering statewide and economy-wide emissions modelling and analysis to inform the NSW Government's net zero targets, policies and programs
- monitoring and reporting on progress towards meeting NSW's net zero targets, including the impact of the NSW Government's net zero programs on NSW emissions.

NSW emissions are projected by year to 2050, taking an economy-wide sectoral approach consistent with international guidelines adopted by the *United Nations Framework convention on climate change* (UNFCCC; UN 1992; see also IPPC 2006; IPCC 2009), using the categories and naming conventions used by the Australian Government's Department of Climate Change, Energy, the Environment and Water (Cth DCCEEW) for national emissions projections.

Emissions projections are prepared using the latest available activity data, peer-reviewed methods and expert assumptions, and indicate what NSW's future emissions could be if the assumptions underpinning the projections occur. Projections are different from forecasts, with forecasts predicting actual future events and changes.

NSW GHG emissions projections include a range of key data inputs, assumptions and methods. Emission projections represent 'scenario modelling' and are the best estimate of a future scenario under the various assumptions applied at a point in time. This methods paper summarises the emissions trends and describes the assumptions and methodologies applied in preparing the projections.

Emissions projections are updated annually to integrate the latest data and information and to account for progress being made to deliver abatement under the Net Zero Plan and related policies and programs.

Scenarios

Projections of direct (scope 1) GHG emissions (i.e. emissions into the atmosphere as a direct result of an activity) have been developed for business as usual (BAU) scenario (previously referred to as 'base case') and current policy scenarios, to support tracking progress towards achieving NSW's net zero emissions objectives.

GHG emission estimates are expressed as carbon dioxide equivalent (CO_2-e) using the 100-year global warming potentials in the Intergovernmental Panel on Climate Change (IPCC) *Fifth assessment report* (Myhre et al. 2013). Although the *Sixth assessment report* released in August 2021 (IPCC 2021) has adjusted global warming potentials, NSW emissions projections use the *Fifth assessment report* global warming potentials for consistency with the National Greenhouse Accounts.

The **BAU scenario** excludes the impact of the Net Zero Plan and related policies but accounts for the impact of other external factors. Such factors include the ongoing impacts of the COVID-19 pandemic, climate, global and local technology and energy shifts, land management changes, sectoral trends and changes in economic growth, and the broader policy context. The BAU emission trajectory by year out to 2050 informs the level of additional effort required to progress towards achieving NSW's net zero objectives.

Current policy emissions projections are developed based on the BAU scenario but account for emissions reductions projected to be achieved by the NSW Government's programs and related policies. The current policy definition includes emissions reductions due to:

- current actions under stage 1 of the Net Zero Plan, including strategies, plans and programs
- related policies, including policies and actions such as the NSW Environment Protection Authority (EPA) *EPA Climate Change Policy* (EPA 2023a) and *EPA Climate Change Action Plan 2023–26* (EPA 2023b) (referred to collectively as EPA climate change policy and action plan or CCPAP) and the Australian Government's Safeguard Mechanism reforms
- future initiatives related to reducing emissions and clean energy by the government supported by the NSW Climate Change Fund under stages 2 and 3 of the Net Zero Plan over 2030–2050.

Two **abatement scenarios** are presented for the current policy projections, as follows:

- program/policy abatement as originally designed
- program/policy abatement as currently tracking.

For some sectors, these scenarios are the same, that is program/policies are currently tracking as originally designed, and in this case only a single projection trend is presented. In other sectors, due to uncertainty in certain programs/policies, projections are presented for both the abatement as originally designed scenario and the more cautious abatement as currently tracking scenario. The difference between these scenarios is described for each sector.

Emissions projection results

The overall business and usual (BAU) and current policy emissions projections for New South Wales are presented and discussed in this section, with the trends, assumptions, methods and results for specific sectors provided in subsequent sections.

Tracking to NSW 2030 and 2035 targets

NSW emissions were inventoried to be 132 million tonnes carbon dioxide equivalent (Mt CO_2-e) for 2021, representing 28% of Australia's total emissions and an 18% (29 Mt CO_2-e) reduction on 2005 levels (Cth DCCEEW 2023b,c,d).

Under the BAU scenario, NSW's emissions are projected to decrease to 102 Mt CO_2-e in 2030, which is 36% below 2005 levels, and to 85 Mt CO_2-e in 2035, which is 47% below 2005 levels (Figure 1, Table 1). While a range of factors have contributed to a revised BAU emissions trajectory, the majority of the downward revision is due to updated modelling for the electricity sector, and the adoption of a significantly different BAU compared to what was originally projected in 2021 under the *Electricity Infrastructure Roadmap* (NSW Government 2020a) modelling. Further detail is provided in the sectoral summary for electricity.

To account for uncertainty in some programs/policies, 2 abatement scenarios are presented for current policy, as follows:

- program/policy abatement as originally designed
- program/policy abatement as currently tracking.

Under the abatement as originally designed scenario, New South Wales remains on track to achieving its targets, achieving 50% below 2005 levels in 2030 and 70% below 2005 levels in 2035. However, when abatement uncertainty in some programs/policies is considered, a more cautious outlook under the abatement as currently tracking scenario indicates more work may be needed. Accounting for this abatement uncertainty, New South Wales is projected to be 44% to 50% below 2005 levels by 2030 and 65% to 70% by 2035.

To remain on track for the 50% target in 2030 and 70% target in 2035, the abatement as originally designed scenario assumes:

- the electricity sector continues to decarbonise consistent with the preferred development pathway under the Electricity Infrastructure Roadmap
- decarbonisation at high emitting industrial facilities continues as designed, supported by EPA's climate change policy and action plan (CCPAP; EPA 2023a,b), the Commonwealth's Safeguard Mechanism reforms (Cth DCCEEW 2023a) and the Net Zero Industry Innovation Program (NZIIP)
- all obligations under Safeguard Mechanism reforms for NSW facilities would need to occur in New South Wales (including offsetting), which would replace reduced

abatement anticipated under the Primary Industries Productivity and Abatement Program (PIPAP)

- abatement designed to be achieved by other programs and sectors continues as expected.

Under the more cautious abatement as currently tracking scenario, assumptions that have a higher level of uncertainty in the land, industrial and agriculture sectors are removed, as follows:

- NZIIP has indicated that it will not achieve the original targets as set out in their original business case and cost–benefit analysis (CBA). For the cautious scenario, revised estimates are used to replace the original targets for the program. This will also avoid potential double counting of emission reductions that occur under Safeguard Mechanism declining baselines for industrial facilities
- no additional offsetting is assumed for New South Wales to meet obligations under the Safeguard Mechanism, beyond what is included in Australian carbon credit units (ACCU) (CER 2024) supply forecasts
- the assumed adoption rates and abatement efficiency for feed additives in agriculture are reduced, following recommendations from the independent peer review.

NSW's BAU and current policy projections are shown in Figure 1 and summarised in Table 1.

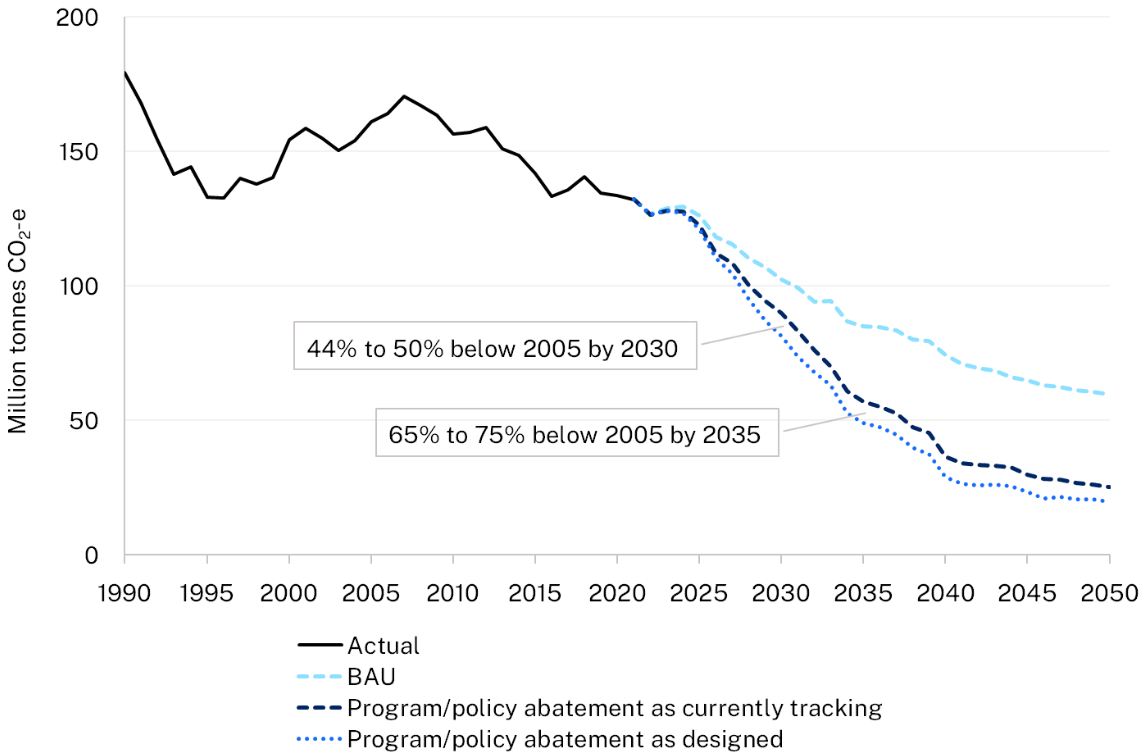

Figure 1 **NSW greenhouse emissions as inventoried (1990–2021) and projected BAU and current policy scenarios (2022–2050)**

Table 1 **NSW emissions as inventoried (2005, 2021) and the projected range (2030, 2035, 2050) compared to NSW emissions reduction targets**

	NSW Greenhouse Inventory		Projected NSW emissions		
	2005	2021	2030	2035	2050
BAU (Mt CO_2-e) Reduction below 2005	161.1	132.0 –18%	102 –36%	85 –47%	59 –63%
Current policy (Mt CO_2-e) Reduction below 2005	na	na	81 to 90 –50% to –44%	49 to 57 –70% to –65%	22 to 25 –87% to –84%
NSW emissions reduction targets	na	na	50% below 2005 levels	70% below 2005 levels	Net zero emissions

Emission reductions by sector

Projected reductions in NSW emissions by sector over 2021–2035, including reductions under the BAU and the abatement as currently tracking scenario are shown in Figure 2. Much of the reduction in NSW emissions under this scenario is projected to come from electricity generation (accounted for in the base case and current policy trajectory) due to the uptake of renewable energy and supported by state and federal policies. The electricity sector contributes almost 30% to cumulative emission reductions to 2035, followed by transport (17%), stationary energy (16%), industrial processes and product use (IPPU) (9%), waste (9%), fugitives (8%), agriculture (6%) and land use, land-use change and forestry (LULUCF) (6%).

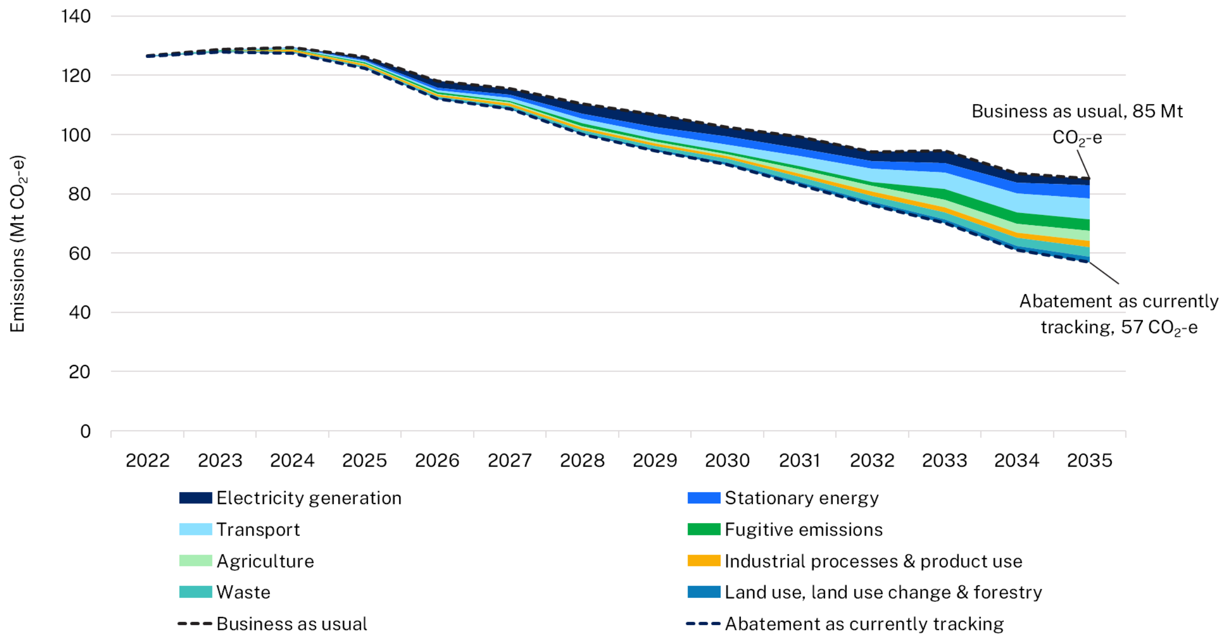

Figure 2 **Projected reduction in NSW emissions by sector over 2022–2035 under the program/policy abatement as currently tracking scenario**

The difference in emissions by sector between the abatement as originally designed and the abatement as currently tracking scenario are shown in Figure 3. Reading the chart from left to right, higher emissions are evident in the IPPU, LULUCF, stationary energy and agriculture sectors for the abatement as currently tracking scenario. Reading the chart from right to left shows the additional step change emissions reductions by sector under the abatement as originally designed scenario, and thus needed to achieve target in 2035.

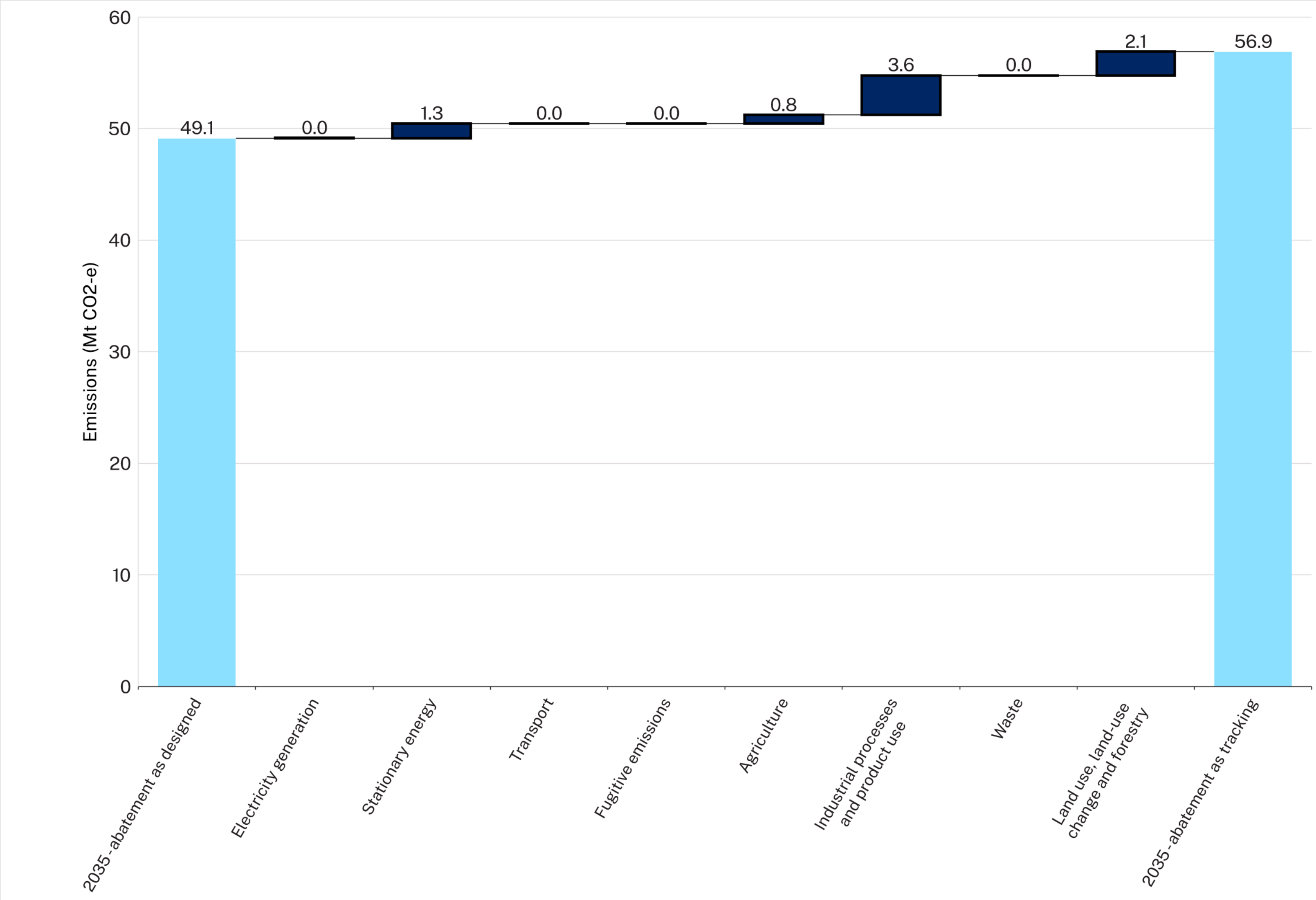

Figure 3 **Difference in emissions by sector in 2035 between the abatement as originally designed and abatement as currently tracking scenarios**

Emission trends under the business as usual scenario

NSW electricity generation emissions are projected to reduce as the share of renewables in the National Electricity Market increases, while emissions from transport and mining are projected to persist or increase in the period to 2030 before decreasing in latter decades.

Annual fugitive emissions from coal mining and gas production and supply are projected to grow by 32% over 2021–2030, primarily as a result of coal mine extensions and mining of more methane-rich coal seams.

Transport emissions are projected to decline very little from 2021 to 2030 (−0.5%) with emissions reductions due to electric vehicle uptake and higher work-from-home rates offset by increased vehicle activity, growth in the share of sport utility vehicles and light commercial vehicles, and increasing emissions from trucks and aviation.

The net sink in the LULUCF sector is projected to grow only slightly from 2021 to 2030, with emissions from plantation harvesting and the conversion of forests to agricultural and other land uses offset by sequestration by forests.

The difference in inventoried emissions for 2021 and projected emissions in 2030 for the waste, stationary energy and industrial processes sectors is in part due to method differences. Waste emissions projections are higher than inventoried due to bottom-up modelling of landfill and wastewater treatment emissions in the NSW projections. The more detailed projection of stationary energy and IPPU sector emissions, however, results in lower emissions being projected when compared with inventory estimates for some subsectors.

Some of the decline in the IPPU sector is due to the phase-down of hydrofluorocarbon (HFC) imports under federal policies, with corporate commitments also contributing to the emissions reductions projected within the IPPU and stationary energy sectors. Further discussion on sector-specific methods and results is in subsequent sections.

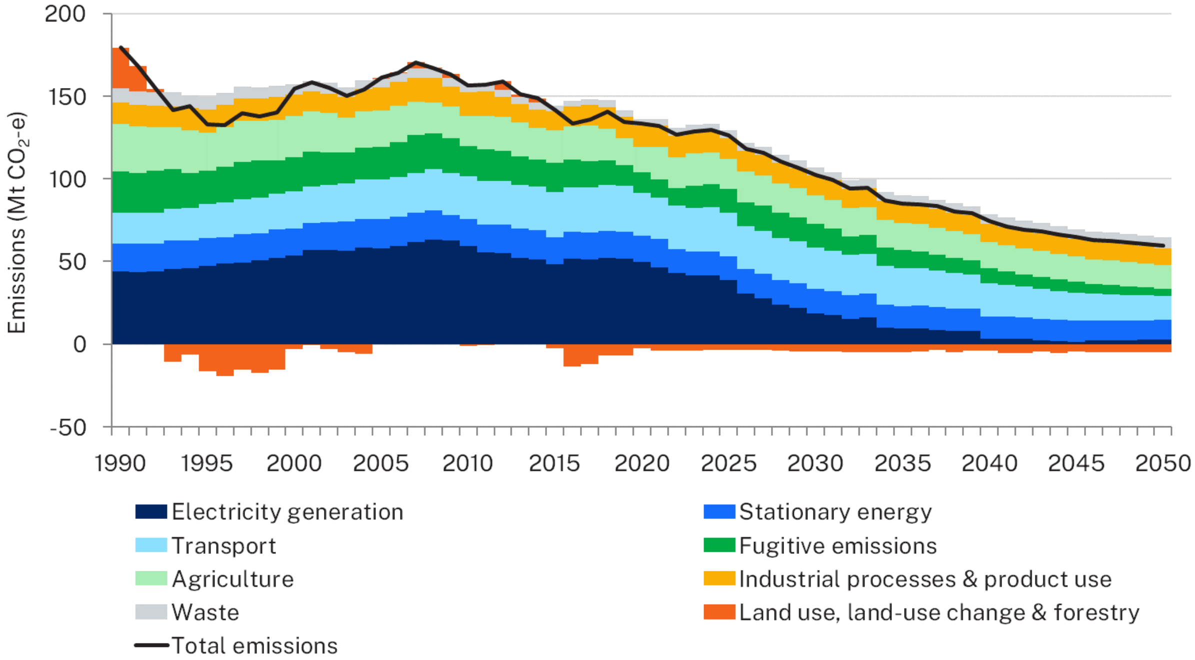

Figure 4 NSW emissions by sector showing inventory estimates (1990–2021) and business as usual (BAU) emissions projections (2022–2050)

Table 2 NSW sectoral emissions as inventoried and projected for the business as usual (BAU) scenario

Sector	NSW Greenhouse Inventory ($Mt CO_2$-e)		BAU projections ($Mt CO_2$-e)			
	2005	2021	2030	2035	2040	2050
Electricity generation	58.1	46.6	19	9	3	3
Stationary energy	17.4	17.0	15	14	13	12
Transport	23.9	25.2	25	23	20	15
Fugitive emissions	19.8	11.0	14	11	9	4
Agriculture	21.9	19.4	17	17	16	14
Industrial processes and product use	13.9	13.0	12	12	11	10
Waste	5.5	4.0	5	5	6	6
Land-use change and forestry	0.5	−4.0	−5	−5	−4	−5
Total emissions	**161.1**	**132.0**	**102**	**85**	**74**	**60**

Emission trends under the current policy scenario

Inventoried emissions and current policy emissions projections by sector are shown in Figure 5, for the cautious abatement as currently tracking scenario. The range in current policy emissions projections for the abatement as originally designed and the abatement as currently tracking scenario are summarised in Table 3.

Table 3 NSW sectoral emissions with current policy scenario projections range

Sector	NSW Greenhouse Inventory ($Mt\ CO_2$-e)		Current policy projections ($Mt\ CO_2$-e)			
	2005	2021	2030	2035	2040	2050
Electricity generation	58.1	46.6	16	7	1	3
Stationary energy	17.4	17.0	11 to 12	8 to 9	5 to 7	5
Transport	23.9	25.2	23	16	10	5
Fugitive emissions	19.8	11.0	14	7	5	2
Agriculture	21.9	19.4	16	12 to 13	10 to 11	10 to 11
Industrial processes and product use	13.9	13.0	7 to 11	6 to 9	3 to 6	3 to 4
Waste	5.5	4.0	4	2	2	2
Land-use, land use change and forestry	0.5	−4.0	−9 to −5	−9 to −7	−7 to −5	−8 to −6
Total emissions	**161.1**	**132.0**	**81–90**	**49–57**	**29–36**	**22–25**

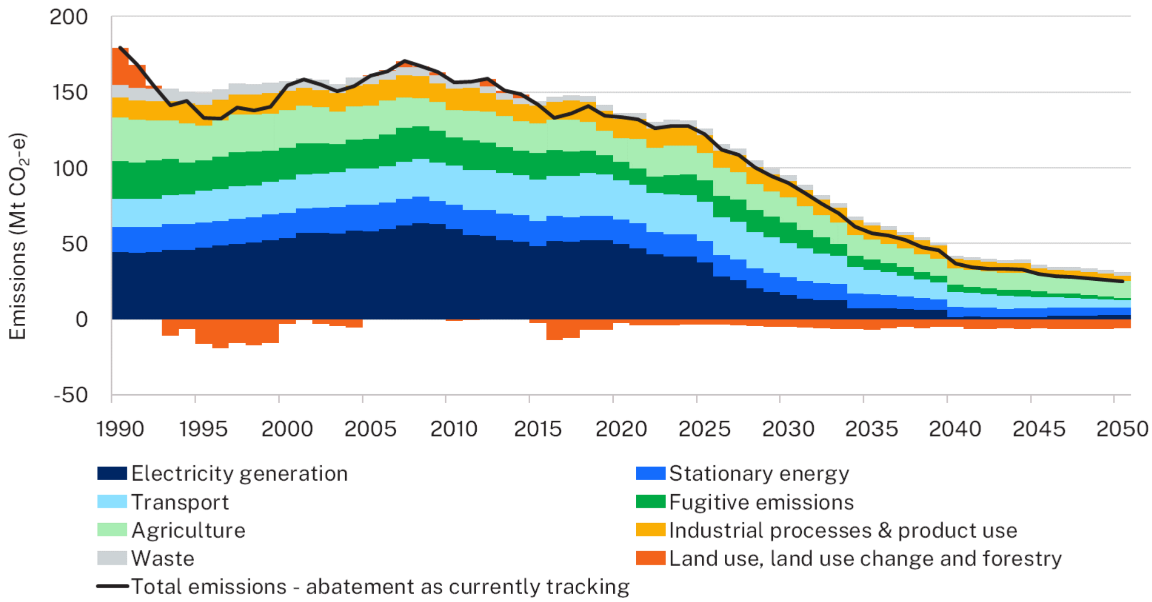

Figure 5 **NSW emissions by sector showing inventory estimates (1990–2021) and emissions projections under the program/policy abatement as currently tracking scenario (2022–2050)**

Current policy abatement as currently tracking to 2035

Notwithstanding the abatement uncertainty for some programs/policy projections, nearer-term sector emissions projections have higher confidence levels given they are based on known policies and programs and bottom-up modelling of abatement.

Much of the reduction in NSW emissions over 2022–2030 is projected to come from electricity generation, supported by the NSW *Electricity Infrastructure Roadmap* (NSW Government 2020a). The electricity sector contributes 29% to cumulative emission reductions to 2030 and 28% to cumulative emission reductions to 2035.

NSW Government policies addressing transport sector emissions include the *NSW Electric Vehicle Strategy* (NSW Government 2021), the *NSW Hydrogen Strategy* (DPIE 2021f), the *Zero Emission Bus Transition Strategy* (TfNSW 2022a), the *Future Transport Strategy* (TfNSW 2022b) and *Towards Net Zero Emissions: Freight Policy* (TfNSW 2023). NSW Government policies support cumulative transport sector emissions reductions of 17% over 2022–2030 and 19% over 2022–2035, driven substantially by reductions in road transport/light vehicle emissions.

Emissions from the stationary energy sector are projected to decrease due largely to increased electrification of mining and manufacturing processes supported by several NSW Government policies and programs (see Table 5 below). Cumulative stationary energy sector emissions reductions of 16% occur over 2022–2035.

The NZIIP has indicated that it will not achieve the original targets as set out in their original business case and CBA, and the program is undergoing review and redesign in 2024. For the more cautious abatement as currently tracking scenario, there is less abatement assumed in stationary energy and IPPU under this program. Cumulative IPPU sector emissions reductions of 10% occur over 2022–2035.

Options have been identified to abate methane (CH_4) emissions at NSW coal mines, and the NZIIP and Coal Innovation NSW (CINSW) funded South32 Ventilation abatement demonstration facility project addresses the abatement of fugitive emissions. It is anticipated the NSW EPA CCPAP and the reform of the Safeguard Mechanism by the Australian Government can support the adoption of available technologies leveraging investments under the Net Zero Plan. This would then help achieve cumulative sector emissions reductions of 8% over 2022–2035.

Enteric CH_4, primarily from cows and sheep, represents the largest source of emissions within the IPCC agriculture sector (13.4 Mt CO_2-e, 70% of agriculture emissions in 2021). There is significant, feasible potential to abate enteric CH_4 emissions in New South Wales from feedlot and dairy cattle through dietary modification, with lower levels of abatement for other cattle and sheep (Almeida and Hegarty 2021). New South Wales is a major agricultural producer with large livestock herds and has the market scale necessary to accelerate commercialisation and adoption of low emissions technologies and practices (OCSE 2020). Leveraging available and emerging abatement technologies and growing environmental markets and corporate commitments (e.g. Meat and Livestock Australia and the National Farmers Federation aim to see Australian agriculture trending towards being carbon neutral by 2030), NSW Government policies and investment are projected to support cumulative agriculture sector emissions reductions of about 5% over 2021–2030 and 6% over 2020–2035.

Emissions reductions are projected for actions under the *NSW Waste and Sustainable Materials Strategy 2041, Stage 1: 2021–2027* (DPIE 2022b), which target a 10% reduction in waste generation and a 50% reduction in organics disposed to landfill by 2030. This strategy also has provision for increased landfill gas capture with associated funding support, supporting cumulative waste sector emissions reductions of about 9% over 2021–2030 and 2020–2035.

NSW Government policies and programs addressing agriculture and LULUCF sector emissions include the Primary Industries Productivity and Abatement program (DPIE 2022a), the *NSW Blue Carbon Strategy 2022–2027* (DPE 2022b) and the NSW National Parks and Wildlife Service *Carbon positive by 2028* plan (NSW Government 2022b). Abatement under PIPAP has been updated for this latest projection update, to reflect changes to the funding profile, changes to co-investment and implementation delays. Other recent policies addressing land management with implications for land sector emissions and sequestration include the *Land Management (Native Vegetation) Code 2018* (see DPE 2022c). The LULUCF sector is projected to achieve cumulative sector emissions reductions of 6% occur over 2022–2030 and 2022–2035.

Current policy emissions projections 2035–2050

Emissions projections for post-2030 reflect ongoing emissions reductions due to the impact of Net Zero Plan Stage 1 programs and related policies, and further abatement forecasts for future actions under stages 2 and 3 of the plan. Longer term sector emissions projections are less certain due to assumptions regarding the sector and abatement pathways to be targeted by future actions under stages 2 and 3 of the Net Zero Plan.

Emissions projected to be abated by sector under stages 1 to 3 of the Net Zero Plan and related policies are illustrated in Figure 6, with the extent of unabated emissions also shown. Emissions reductions from electricity generation reduce after the latter half of the 2030s given the closure of all remaining coal-fired powered stations by 2040.

New South Wales's emissions are projected to reduce to 22 to 25 Mt CO_2-e by 2050, indicating that further investment and breakthrough technologies and practices will be needed in latter decades to address residual emissions and achieve the legislated net zero emissions target by 2050.

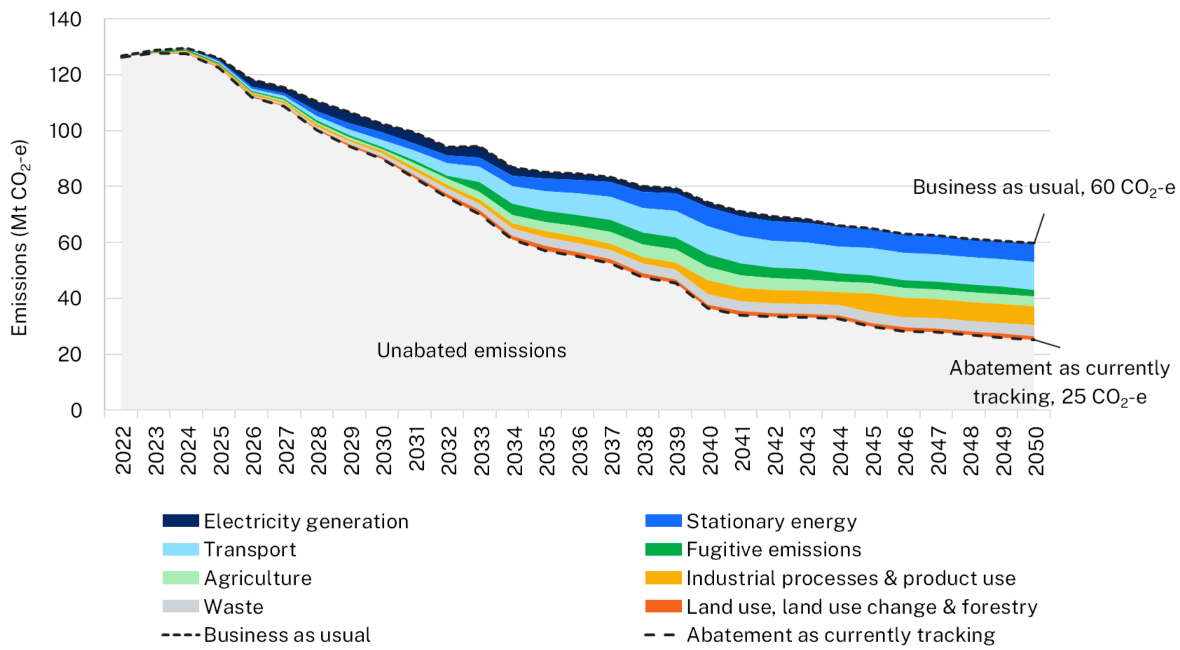

Figure 6 **Projected reduction in NSW emissions by sector over 2022–2050 under the abatement as currently tracking scenario**

Remaining (residual) emissions by sector for the cautious outlook current policy scenario are shown for selected years in Figure 7. Such emissions include hard to abate sources within agriculture, transport, mining, manufacturing and buildings, and legacy waste emissions. Further information is provided in subsequent sections on sector-specific residual emissions.

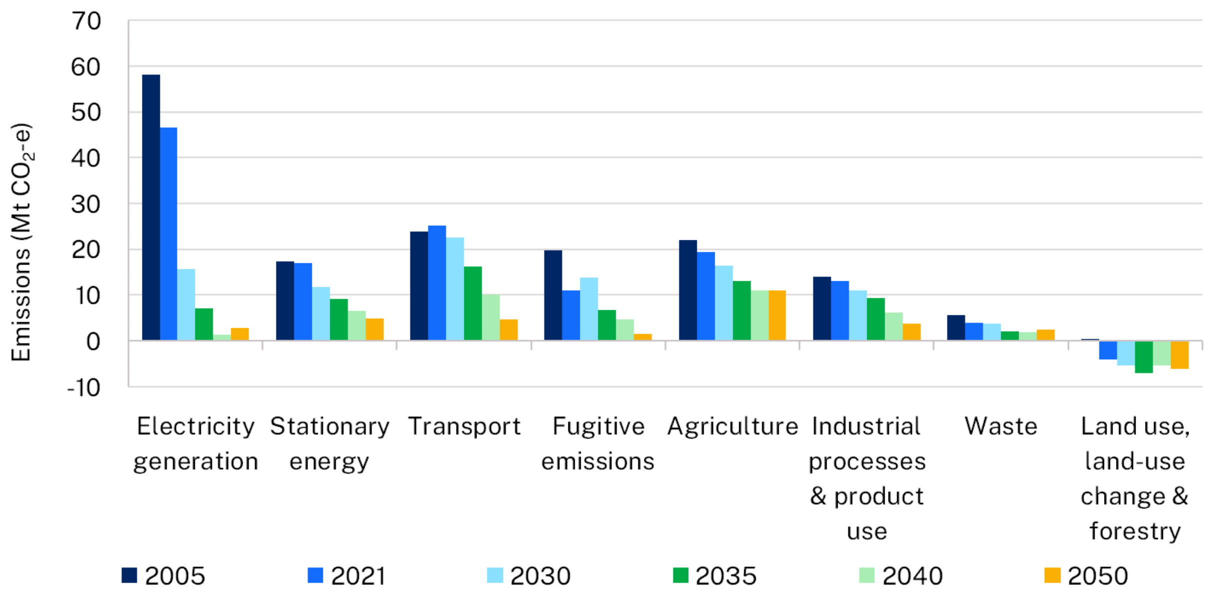

Figure 7 **NSW emissions by sector for selected years based on inventory estimates (2005, 2021) and under the abatement as currently tracking scenario for future years**

Comparison with 2022 emissions projections

Business as usual

In 2022, BAU (previously referred to as 'base case') emissions were projected to be 110 Mt CO_2-e in 2030 and 102 Mt CO_2-e in 2035. In the 2023 updated BAU, NSW emissions are revised to be 102 Mt CO_2-e in 2030 and 85 Mt CO_2-e in 2035 (Figure 8).

While a range of factors have contributed to a revised BAU emissions trajectory, the majority of the downward revision is due to the electricity sector and the adoption of a significantly different BAU compared to what was originally projected in 2021 under the original *Electricity infrastructure roadmap* modelling.

Across other sectors, BAU projections are based on the latest commodity forecasts and account for potential new manufacturing. The projections also include potential emissions from gas projects, coal mining extensions and plausible new coal mining within strategic releases.

It is also noted that inventoried emissions for New South Wales in 2021 (released in 2023) were higher than what was estimated for that year in the 2022 projections release. Therefore the 2023 projections start from a position of higher emissions compared with the previous update (as seen in Figure 8). Further discussion on the changes to the BAU projection for each sector is provided in each sectoral section.

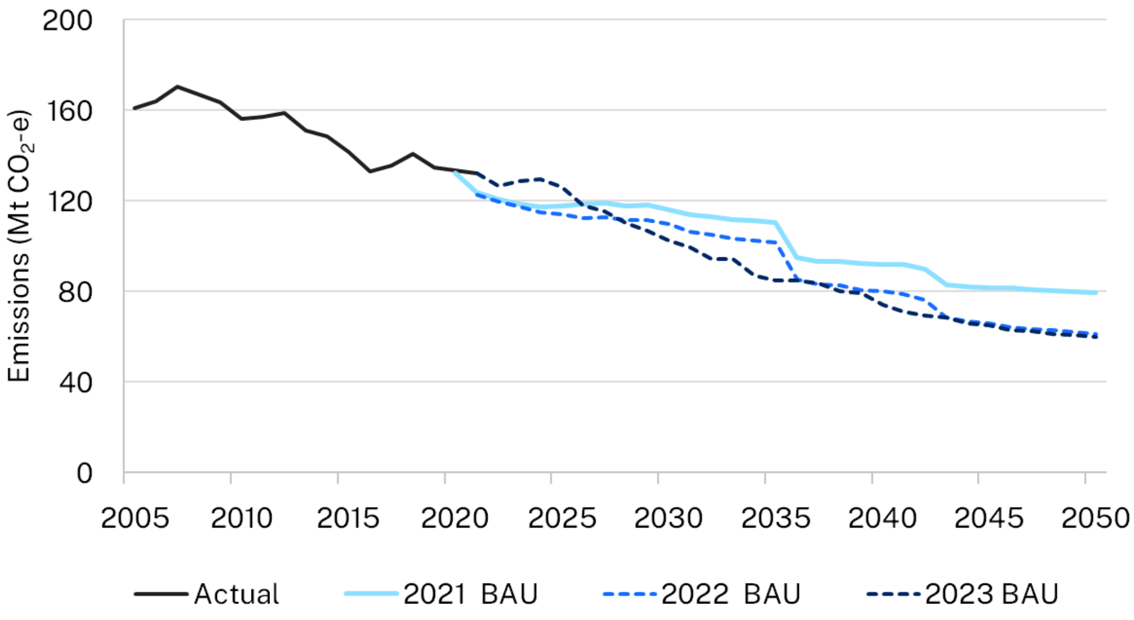

Figure 8 **Comparison of 2021, 2022 and 2023 business as usual (BAU) projections for NSW emissions (projected emissions excluding the Net Zero Plan and related policies)**

Current policy

In 2022, current policy emissions were projected to be 71 Mt CO_2-e in 2030 and 48 Mt CO_2-e in 2035. In comparison, in the 2023 updated current policy, NSW emissions are revised to be in the range 80 to 90 Mt CO_2-e in 2030 and 49 to 57 Mt CO_2-e in 2035 (Figure 9). The range in emissions reflects the 2 abatement scenarios considered: abatement as originally designed and abatement as currently tracking.

In 2030 there is an additional 10 to 19 Mt CO_2-e in the latest projections update, resulting in a drop from 56% below 2005 in last year's projections to 44 to 50% below 2005 in this year's projections. Of this additional 10 to 19 Mt CO_2-e, about 9 Mt comes from the electricity and stationary energy sectors. There is about 5 Mt less abatement in the land and agriculture sector due to revised funding under PIPAP, and in the abatement as currently tracking scenario there is about 7 Mt less abatement across industry due to revised program abatement under NZIIP.

In 2035, there is an additional 1 to 9 Mt CO_2-e in the latest projections update. Of this additional 1 to 9 Mt, 5 Mt comes from the electricity and stationary energy sectors, while 5 Mt lower emissions in transport and fugitives is offset by less abatement under NZIIP and PIPAP.

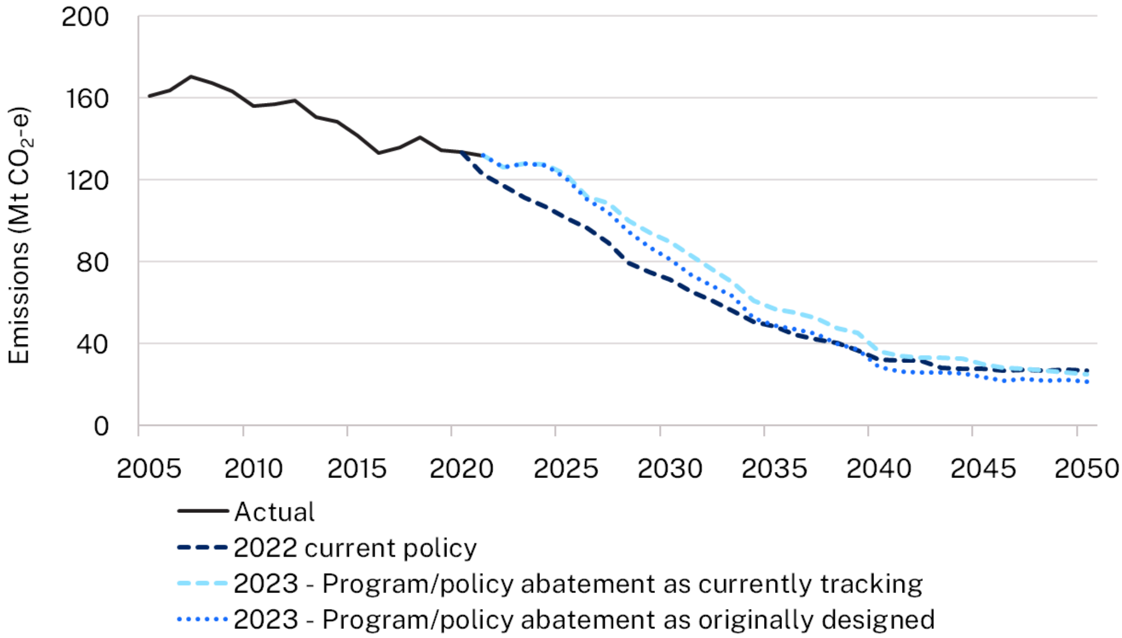

Figure 9 **Comparison of 2022 and 2023 current policy projections scenarios for NSW emissions**

Overview of the methodology

Sectors

Projections are prepared at a sectoral level consistent with international guidelines adopted by the *United Nations framework convention on climate change* (UNFCCC; UN 1992), using the categories and naming conventions used by the Australian Government Department of Climate Change, Energy, the Environment and Water (Cth DCCEEW) for national emissions projections (Table 4) (Cth DCCEEW 2023d,e,f,g).

Emission factors used are generally consistent with the *National inventory report 2021*, published in April 2023 (Cth DCCEEW 2023e,f). Reporting years are financial years, and so cover the 12 months ending 30 June of that year.

Table 4 **Description of *United Nations framework convention on climate change* (UN 1992) sector and subsector classifications**

UNFCCC classification sector and subsector	Naming of sectors for projections
1. Energy (combustion + fugitive)	
Stationary energy	
Public electricity and heat production	Electricity generation
Stationary energy (all other excluding public electricity and heat production)	Stationary energy
Transport	Transport
Fugitive emissions from fuel	Fugitives
2. Industrial processes and product use	Industrial processes and product use (IPPU)
3. Agriculture	Agriculture
4. Land use, land-use change and forestry	Land use, land-use change and forestry (LULUCF)
5. Waste	Waste
Total net emissions	Total net emissions

Reporting boundaries

Reporting boundaries are consistent with the NSW Greenhouse Gas Inventory. Direct (scope 1) emissions are accounted for in the projections to support the assessment of progress towards achieving NSW's net zero objectives, and consistent with national emissions projections supporting Australia's reporting of progress towards commitments under the Paris Agreement (United Nations 2015).

Emissions are projected from 2022–2050, with reference made to inventoried emission estimates for 1990–2021 (latest inventory year published at the time projections were prepared) (Cth DCCEEW 2023d).

Indirect emissions (scopes 2 and 3), lifecycle carbon and embodied carbon are not addressed in the business and usual (BAU) and current policy projections documented in this methods paper.

The NSW projections for aviation and waterborne navigation reflect the reporting boundaries adopted by the Australian Government for the National Greenhouse Accounts to support reporting to the UNFCCC. The National Greenhouse Accounts include emissions from:

- **domestic aviation** from civil domestic passenger and freight traffic that departs and arrives in Australia, including take-offs and landings for these flight stages and travel between airports, excluding military aviation
- **domestic waterborne navigation**, including emissions from fuels used by vessels of all flags that depart and arrive in Australia.

Fuels used in international transport (international aviation and bunker fuels) are estimated by the Australian Government but are reported separately as a memo item under an international agreement that such items be reported separately from national total net emissions. The Australian Government calculates emissions for domestic aviation and navigation for specific fuel types based on fuel consumption data from the Australian Energy Statistics (AES). Emissions are allocated to states and territories based on fuel consumption by jurisdiction, as reported within the AES and *Australian Petroleum Statistics*.

Policies and programs supporting emissions reduction

Integrated emissions modelling for NSW Government actions ensures an optimal portfolio of net zero emissions policies and programs, accounting for cross-sector trade-offs and interdependencies. This included the delivery of an integrated, ex-ante emissions abatement trajectory for the Net Zero Plan Stage 1 programs, to support sectoral current policy projections and monitoring and reporting on the impact of the plan on total NSW emissions. The abatement projected for net zero programs is generally based on one of the following:

- ex-ante emission projections developed for cost–benefit analysis (CBA) in program design and business cases
- updated ex-post-emission projections due to revised funding profiles, implementation delays or changes to program design
- top-down modelling of potential abatement based on funding
- targets for abatement outlined in strategies or initiatives.

The integrated current policy projections include the emissions abatement trajectory for Net Zero Plan Stage 1 programs and related NSW Government actions, as well as other related policies and actions anticipated in the near term, and future actions by the NSW Government under stages 2 and 3 of the plan. These programs and policies are summarised in Table 5.

Table 5 **Net zero programs and related policies considered in the 2023 current policy projections**

Current policy category	Policies and programs	Sectors
Abatement assumed under Net Zero Plan programs and related NSW Government action	*NSW Electric Vehicle Strategy* (NSW Government 2021)	Transport
	Zero Emission Bus Transition Strategy (TfNSW 2022a)	Transport
	Towards Net Zero Emissions: Freight Policy (TfNSW 2023)	Transport
	Electricity Infrastructure Roadmap (NSW Government 2020a)	Electricity generation
	Energy Security Safeguard (NSW Government 2020b)	Electricity generation
	Peak Demand Reduction Scheme (NSW Government 2022d)	Electricity generation
	Net Zero Industry and Innovation Program (NZIIP) (DPIE 2021c)	IPPU, Stationary energy, Fugitive emissions
	NSW Hydrogen Strategy (DPIE 2021f)	IPPU, Stationary energy, Transport
	Business decarbonisation support (DPIE 2021a)	IPPU, Stationary energy
	Safeguard Acceleration Program/*Energy Security Safeguard* (NSW Government 2020b)	Stationary energy
	NSW Net Zero Buildings Initiative (DPIE 2021e)	Stationary energy
	State Environmental Planning Policy (Sustainable Buildings) 2022 (NSW Government 2022e)	Stationary energy
	NSW Waste and Sustainable Materials Strategy 2041 (DPIE 2022b)	Waste
	Primary Industries Productivity and Abatement program (DPIE 2022a)	Agriculture and LULUCF
	NSW Blue Carbon Strategy 2022–2027 (DPE 2022b)	LULUCF
	NSW National Parks and Wildlife Service *Carbon positive by 2028* (NSW Government 2022b)	LULUCF

Current policy category	Policies and programs	Sectors
Abatement expected to come from related policies and associated market impacts	*EPA Climate Change Policy* (EPA 2023a) and *EPA Climate Change Action Plan 2023–26* (EPA 2023b)	IPPU, Stationary energy, Fugitive emissions
	Safeguard Mechanism reform by the Australian Government (Cth DCCEEW 2023a)	IPPU, Stationary energy, Fugitive emissions
	2022 Energy Savings Scheme rule changes (NSW Government 2023)	Stationary energy
	Land Management (Native Vegetation) Code 2018 (see DPE 2022c)	LULUCF
Future abatement from committed funding under stages 2 and 3 of the Net Zero Plan	No policies or programs are yet designed	All sectors with residual emissions (excluding electricity and LULUCF)

Consideration of Safeguard Mechanism reform

The Commonwealth's reform of the Safeguard Mechanism requires significant emission reductions across multiple sectors, designed to help deliver a proportional share of Australia's 2030 climate target.

Industrial facilities will need to meet their Safeguard Mechanism declining emissions baseline obligations through a combination of onsite reduction and through the surrender of Australian carbon credit units (ACCUs) or Safeguard Mechanism credits (SMCs). How each facility in New South Wales will meet their obligations is not known at this stage, however, for the purpose of NSW's projections, assumptions are made for some sectors/facilities that a certain amount of onsite abatement can be achieved through technology. Any remaining emission reductions obligations under Safeguard Mechanism declining emissions baseline will need to occur through industry surrendering ACCUs or SMCs.

The Commonwealth's 2023 emission projections expect demand for ACCUs to increase from 1 million ACCUs in 2022 to 26 million in 2030 (Cth DCCEEW 2023g,h). The annual issuance of ACCUs is also projected to grow steadily from 16–17 million in 2023 to 30 million by 2033, incentivised by projected higher ACCU prices (Cth DCCEEW 2023g,h), with the majority of the ACCUs generated from the land sector.

The Commonwealth's 2023 emission projections assume the implementation of onsite reductions will be driven, in part, by the relative economics of abatement technology and price of ACCUs, with cheaper efficiencies-based reductions initially occurring at facilities. The Commonwealth's 2023 emission projections also account for forecast ACCU supply in New South Wales and across Australia, taking into account existing ACCU projects, increased demand from the Safeguard Mechanism reforms and how much demand could be met through onsite abatement.

The Commonwealth's 2023 emission projections assume more onsite abatement for NSW facilities than is assumed in NSW's projections. Furthermore, the Commonwealth's ACCU supply forecasts do not assume demand for NSW facilities would be met within New South Wales, as there is no such requirement under the Safeguard Mechanism.

Therefore, all obligations for NSW facilities under Safeguard Mechanism reforms are not fully accounted for within New South Wales, although some may be accounted for in the land sector projections, through ACCU supply forecasts.

However, for New South Wales to remain on track to achieving its targets, additional sequestration in the land sector is required. This could be achieved, for example, if NSW facilities requirements under the Safeguard Mechanism (excluding assumed onsite abatement) are able to be offset within New South Wales.

Although there is no current requirement for onsite abatement, or to offset within New South Wales, there is an opportunity for the NSW Government to leverage existing policies and programs, including Net Zero Industry and Innovation Program (NZIIP) and the EPA's climate change policy and action plan (CCPAP; EPA 2023a,b), to prioritise onsite reduction over offsetting where possible. Furthermore, there is additional opportunity and need to prioritise offsetting within New South Wales, to help New South Wales remain on track to achieve its interim net zero targets. For example, in the draft *NSW EPA guide for large emitters*, a GHG emissions management hierarchy is outlined, prioritising onsite emissions reductions over offsetting if possible and a preference for NSW based offsets.

Under the abatement as originally designed scenario, all obligations under Safeguard Mechanism reforms for NSW facilities would need to occur in New South Wales (including offsetting). This is included in the abatement as originally designed scenario as it would effectively replace abatement that was originally designed under the Primary Industries Productivity and Abatement Program (PIPAP) (discussed further below).

Under the more cautious 'abatement as currently tracking' scenario no additional abatement is assumed for Safeguard Mechanism, other than what is already accounted for in onsite abatement and the land sector projections for New South Wales.

Summary of approach to modelling abatement for Stage 2 and 3

The assumptions for ex-ante or ex-post-emissions abatement trajectories for Net Zero Plan Stage 1 programs are described in the sectoral summary chapters below. A different approach was taken for future action under stages 2 and 3 of the Net Zero Plan (program/policy not yet designed). Emission reductions estimates are made through top-down modelling based on committed funding in the NSW Climate Change Fund of around $150 million per year over 2030–2050.

The following assumptions were made:

- $150m of committed funding is available per annum.
- Private sector co-investment is assumed based on a ratio of 1:4.
- The average cost of abatement is $90/tonne (McKinsey 2021), starting at $30/tonne in 2031, increasing to $150/tonne in 2050.
- Outcomes are assumed to be delivered over 10 years (i.e. all abatement from total funds each year doesn't happen in the starting year, it happens over the next 10 years).

The total estimated emissions from stage 2 and 3 funding is then assumed to focus on sectors with significant remaining emissions and abatement opportunities, such as the industry, mining, transport, agriculture and stationary energy sectors. The electricity sector and land use, land-use change and forestry (LULUCF) sector were excluded from this future funding allocation. The emissions reductions are allocated to sectors on a pro-rata basis, based on the relative proportion of residual emissions remaining in each sector.

Peer review and future improvements

The assumptions, inputs and results of the BAU and current policy emissions projections were subject to peer review by independent expert reviewers external to government (ARUP 2024). The peer review concluded the projections to be generally appropriate for projecting potential carbon emissions and program impact out to 2035. Future emissions projections beyond 2035 have a higher degree of uncertainty, as discussed in the final ‘Projection uncertainty’ section of this methods paper.

For most sectors, the peer review concluded that the abatement projections to 2035 have a medium level of confidence. The abatement projections for some sectors/subsectors (i.e. manufacturing stationary energy, agriculture, LULUCF) were identified as having a lower level of confidence.

The feedback from the peer review is addressed by presenting the projection’s range, specifically through the more cautious ‘abatement as currently tracking’ scenario. Other improvements recommended by the peer reviewers will be addressed in the preparation of the next projection update, with focus areas of improvement described in the concluding subsection of each sector chapter.

Electricity generation

This subsector of energy industries covers stationary energy related emissions from fuel combustion in public thermal power stations, including gross electricity generation and any heat produced by such power stations. Public thermal power stations generate electricity and/or heat for sale to third parties as their primary activity.

Summary of the emissions trends

The electricity generation sector emissions projection for business as usual (BAU) and current policy is presented in Figure 10. BAU emissions are projected to decrease from 46.6 Mt CO_2-e in 2021 (20% below 2005 levels) to 18.7 Mt CO_2-e in 2030 (68% below 2005 levels) and 9.2 Mt CO_2-e in 2035 (84% below 2005 levels), due to the growing share of renewable generation.

For this sector, there is no difference between the abatement as originally designed scenario and the 'abatement as currently tracking' scenario, therefore a single current policy projection is presented.

Under current policy, emissions are projected to further reduce to 15.7 Mt CO_2-e in 2030 (73% below 2005 levels) and 7.0 Mt CO_2-e in 2035 (88% below 2005 levels).

The Net Zero Plan programs and policies included in the current policy emissions projections include the *Electricity Infrastructure Roadmap* (NSW Government 2020a) and the *Energy Security Safeguard* (NSW Government 2020b), which are projected to support the acceleration of the state's electricity sector transition.

Annual NSW electricity generation emissions are projected to reduce by 66% over the period 2021–2030 and by 85% over the period 2021–2035. The methodology and assumptions for the BAU and current policy projection are discussed in subsequent sections.

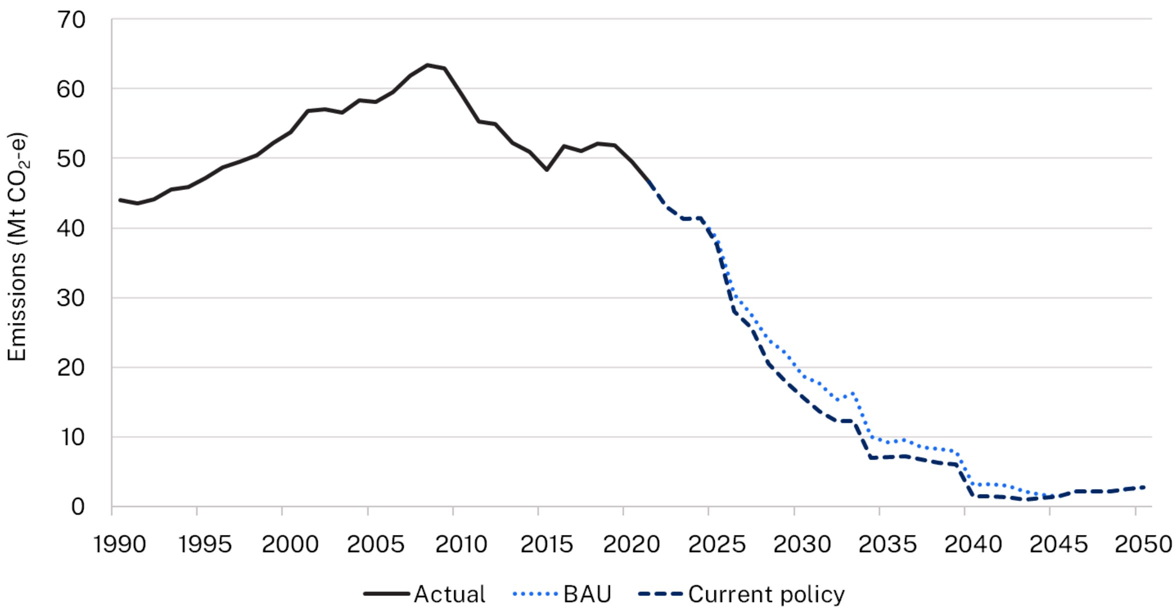

Figure 10 **NSW electricity generation emissions as inventoried (1990–2021), with business as usual (BAU) and current policy emissions projections (2022–2050)**

Summary of changes in emissions since last year's projection update

Previous projections released in 2021 and 2022 (DPE 2022d, 2023) were based on modelling and analysis for the *Electricity infrastructure roadmap*. The latest modelling of the preferred development pathway for the roadmap projects higher emissions in 2030 and 2035.

This is due to an increase in electricity demand forecasts, leading to increased coal generation and a lower share of renewable generation. The latest modelling projects 6.2 Mt more emissions in 2030 and 2.5 Mt more emissions in 2035 compared to the previous projections update.

Methodology and assumptions

Business as usual methodology and assumptions

The updated BAU is based on modelling completed by the NSW Government for a scenario where the *Electricity infrastructure roadmap* is not implemented (OECC 2023). This 'no roadmap' scenario is aligned with the NSW Consumer Trustee *2023 Infrastructure investment objectives report* (AEMO Services 2023), which informs implementation of the roadmap.

Many of the no roadmap modelling inputs, such as electricity demand, rooftop solar, electric vehicle (EV) uptake, hydrogen production and coal-fired generator closures, are aligned with the current policy roadmap modelling.

The revised BAU is significantly different to the previous projections update. Coal-fired generators have announced earlier closures since the Australian Energy Market Operator's (AEMO) *2022 Integrated system plan* (2022 ISP, AEMO 2022a), which was the basis for some of the input assumptions in the previous modelling. For example, in 2020, Eraring Power Station was expected to operate until 2032 and Bayswater Power Station until 2035, but both coal-fired power stations have announced intended earlier closure dates (2025 and 2033, respectively).

The 2022 ISP step change scenario, upon which the roadmap modelling is based, suggests that closures will need to accelerate further to achieve net zero by 2050 and therefore models a more rapid closure of NSW's coal-fired power stations.

Electricity demand assumptions in the no roadmap modelling are consistent with the roadmap modelling, both based on AEMO's 2022 ISP, and represent a significant increase from the previous modelling. Higher electricity demand is driven primarily by updated assumptions for EV uptake and the inclusion of hydrogen production.

The no roadmap modelling is used for BAU projections for the period 2024 to 2043. Post-2043, the projections revert to the 2022 ISP step change scenario. At this point all coal-fired generators are closed.

Current policy assumptions

The greenhouse gas (GHG) emission intensity of electricity supply in New South Wales is expected to reduce significantly in coming decades under the NSW Government's Electricity Infrastructure Roadmap. The enabling legislation for the roadmap, the *Electricity Infrastructure Investment Act 2020* (NSW), was enacted into law in December 2020. The Energy Security Safeguard includes expanding and extending the existing Energy Saving Scheme to 2050 and introducing a new Peak Demand Reduction Scheme.

Emissions reductions to be achieved through the implementation of the Electricity Infrastructure Roadmap are dependent on the development pathway. AEMO Services was appointed in October 2021 as the Consumer Trustee under the NSW Electricity Infrastructure Roadmap. The Consumer Trustee's *2023 Infrastructure investment objectives report* (AEMO Services 2023) outlines the preferred 20-year development pathway for the construction of electricity infrastructure in New South Wales to achieve the infrastructure investment objectives set out in the *Electricity Infrastructure Investment Act 2020*. The infrastructure investment objectives specify minimum amounts of renewable generation infrastructure and long-duration storage infrastructure to be constructed by the end of 2029, as well as additional infrastructure necessary over a 20-year period to minimise costs to NSW electricity customers and meet the NSW energy security target and reliability standard (AEMO Services 2023).

The *2023 Infrastructure investment objectives report* is adopted as the development pathway that best reflects NSW Government current policy under the roadmap. Consistent with the 2022 ISP step change scenario, this modelling assumes earlier coal generator closures than announced.

Similar to the BAU, post-2043, the projections revert to the 2022 ISP step change scenario. At this point all coal-fired generators are closed.

Differences in assumptions and inputs between the no roadmap and roadmap scenarios are set out in detail in the roadmap benefits modelling report (OECC 2023), providing an explanation for the difference in the BAU and current policy trajectory presented in Figure 10. For example, in the no roadmap modelling, policy objectives for renewables and storage capacity were removed as constraints, renewable energy zones are developed reactively based on market signals, and certain projects are included if considered not materially influenced by the roadmap legislation.

Considerations for projection updates

Future modelling in this sector is expected to take into account updated electricity demand forecasts and may consider recently announced policies such as the expansion of the capacity investment scheme and bilateral renewable energy transformation agreements.

Stationary energy (excluding electricity)

Emissions in this sector arise from the burning of fuels for energy production, in the form of heat, steam or pressure (and exclude electricity generation and transport).

Projections for this sector include energy industries (coal, gas), manufacturing industry and construction, and ‘other sectors’, which include primary industries (agriculture, forestry, fishing) and commercial/institutional and residential sectors (buildings).

Summary of the emissions trends

Business as usual

Inventoried emissions (1990–2021) and business as usual (BAU) emissions projections (2022–2050) for the stationary energy subsectors are shown in Figure 11. BAU emissions are projected to be relatively steady over the medium term. Emissions remain at approximately 14.5 Mt CO_2-e in 2030, decreasing to 13.6 Mt CO_2-e in 2035 and 11.7 Mt CO_2-e in 2050.

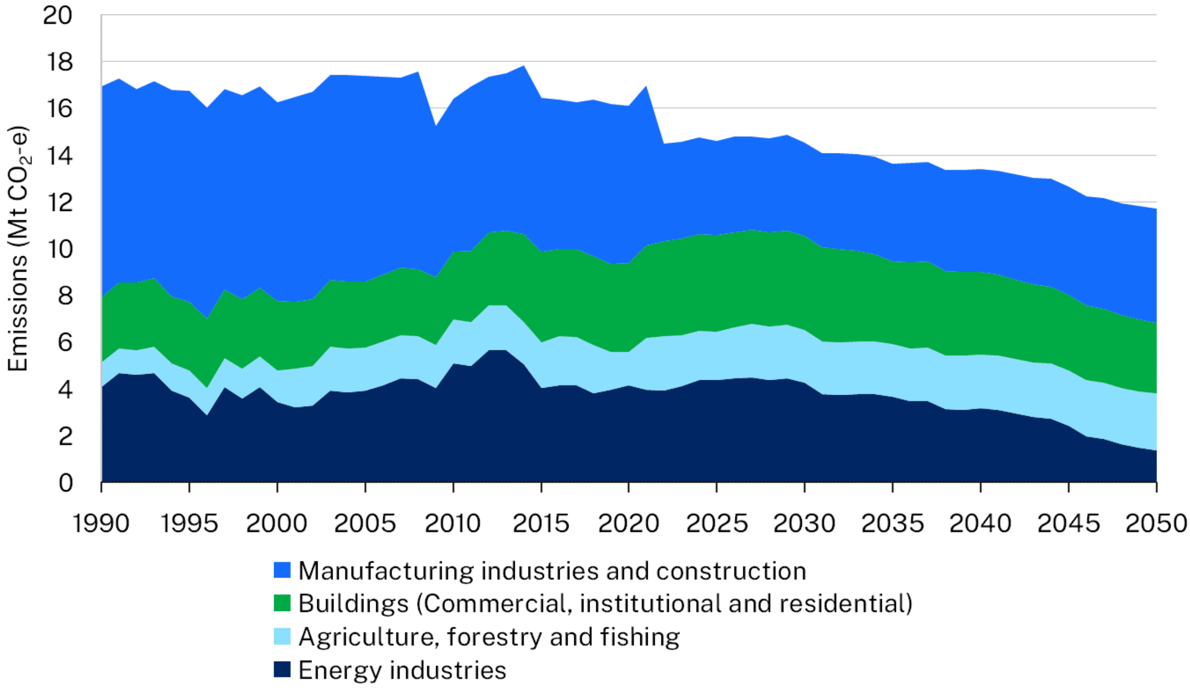

Figure 11 **Stationary energy emissions by subsector showing inventory estimates (1990–2021) and business as usual emissions projections (2022–2050)**

Emissions from manufacturing industries and construction decrease slightly from 4.1 Mt CO_2-e in 2022 to 4.0 Mt CO_2-e in 2030. Primarily due to production increase, emissions are projected to grow to 4.2 Mt CO_2-e in 2035, then increase to 4.9 Mt CO_2-e by 2050. It is noted that there is a drop evident in the graph for manufacturing industries between 2021 and 2022, due to a reporting difference between National Greenhouse and Energy Reporting Scheme (NGERS) and State and Territory

Greenhouse Gas Inventory (STGGI) data for the chemicals subsector (described further in methodology below).

The emissions from energy industries increase from 3.9 Mt CO_2-e in 2022 to 4.3 Mt CO_2-e in 2030, mainly due to increasing emissions from gas production and distribution. In 2030, over 80% of the stationary energy emissions within the energy industries category are projected to be from diesel consumption at primarily open-cut coal mines. Diesel is used to power mobile plant and equipment such as haul trucks, dozers and loaders, with a smaller share being used for stationary power. Due to emission reductions in coal mining, the emissions of the energy industries sector are projected to decrease to 3.7 Mt CO_2-e in 2035, then to 1.4 Mt CO_2-e by 2050.

The emissions from the other sectors are similar between 2022 to 2030. The emissions from other sectors decrease to 5.8 Mt CO_2-e in 2035, and then to 5.4 Mt CO_2-e in 2050, due to increasing electrification, more energy-efficient equipment and appliances, and energy efficiency improvements in buildings (commercial, institutional and residential). The emissions from agriculture, forestry, fishing remain in the range 2.1–2.4 Mt CO_2-e in the medium and long term mainly from diesel consumption for on-farm vehicles and machinery.

The methodology and assumptions for the BAU scenario are discussed in subsequent sections.

Current policy

Abatement in this sector is projected to come from fuel switching and electrification supported by net zero programs including Net Zero Industry and Innovation Program (NZIIP), Business Decarbonisation Support, Safeguard Acceleration Program, Net Zero Buildings Initiative and State Environmental Planning Policy (Sustainable Buildings) 2022 (the Sustainable Buildings SEPP). Opportunities for onsite abatement are considered, leveraged by the Safeguard Mechanism reforms and EPA's climate change policy and action plan (CCPAP, EPA 2023a,b). Future action under stage 2 and 3 funding is also applied for this sector.

To account for uncertainty in abatement that may be able to be achieved in this sector, the 2 abatement scenarios are presented. Under the cautious 'abatement as currently tracking' scenario, abatement that was originally targeted under NZIIP has been revised down, as the program has indicated that it will not achieve the original targets as designed. The program is currently being reviewed and future updates to the projections will incorporate revised abatement projections for the program, including interaction with the Safeguard Mechanism.

For New South Wales to remain on track to achieve its targets, emission reductions equivalent to NZIIP's original targets would be needed, under either NZIIP, Safeguard Mechanism and/or supported by the EPA's CCPAP. This is reflected in the abatement as originally designed scenario.

The integrated abatement that is projected to achieved under the 2 scenarios is shown in Figure 12.

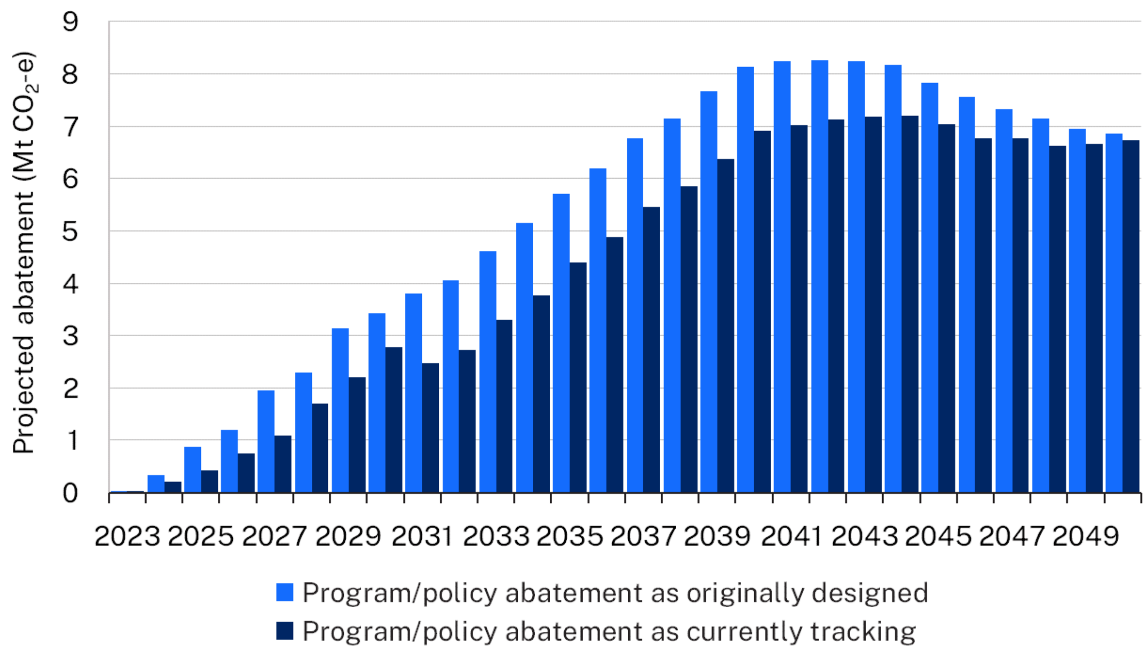

Figure 12 **Abatement projected to be achieved by programs and related policies under current policy scenarios**

The resultant range in current policy projections for this sector is shown in Figure 13. Further details on the assumptions for current policy is presented in subsequent sections. The difference between the abatement as originally designed and the 'abatement as currently tracking' projection is effectively the reduced abatement assumptions under the NZIIP program. Even without NZIIP's original targets, abatement opportunity in this sector is driven by clean technology innovation, hydrogen strategy and other programs, as well as market forces and obligations under the Safeguard Mechanism reforms.

The peer review found that the abatement estimates for industry may be overly optimistic. Only the abatement as originally designed scenario was peer reviewed, therefore this finding is addressed, at least partly, by the inclusion of the more cautious 'abatement as currently tracking' scenario.

It is also noted that the peer review found that other subsectors in stationary energy may be overly conservative, for example, market forces may actually drive additional abatement. Therefore, as a whole, the total abatement for stationary energy (excluding electricity) may be reasonable, even under the abatement as originally designed scenario.

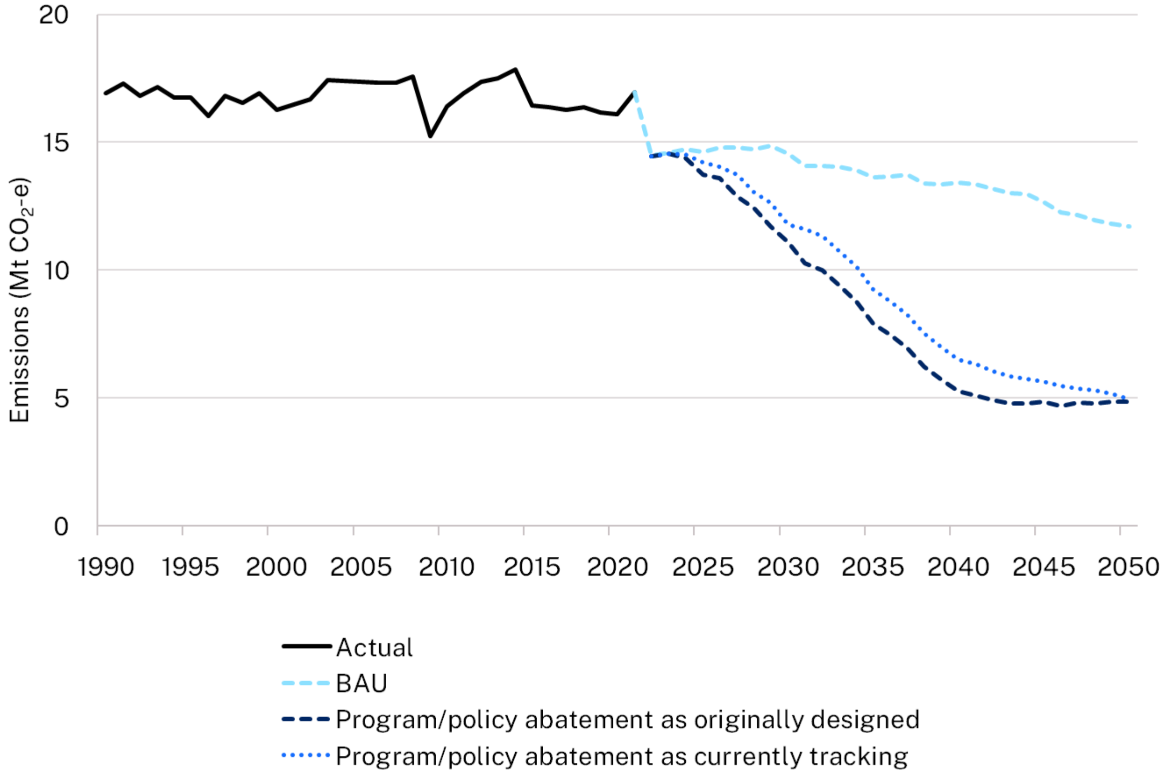

Figure 13 **Comparison of NSW stationary energy (excluding electricity generation) emissions projected under the business as usual (BAU) scenario and under current policy scenarios (2022–2050)**

Summary of changes in emissions since last year's projection update

Figure 14 compares the 2022 and 2023 BAU projections. As described previously, the drop in emissions between 2021 and 2022 (2020 and 2021 in the 2022 BAU) is due to a discrepancy of approximately 2 Mt between the STGGI and NGER's data, with NGER's data used for projections. The 2021 STGGI also reported an increase in emissions from 2020 to 2021, mainly in agriculture, forestry and fishing due to higher diesel consumption; and in the commercia/institutional and residential subsectors due to higher natural gas consumption. This uptick in emissions in 2021 results in a higher BAU trajectory in the latest 2023 update.

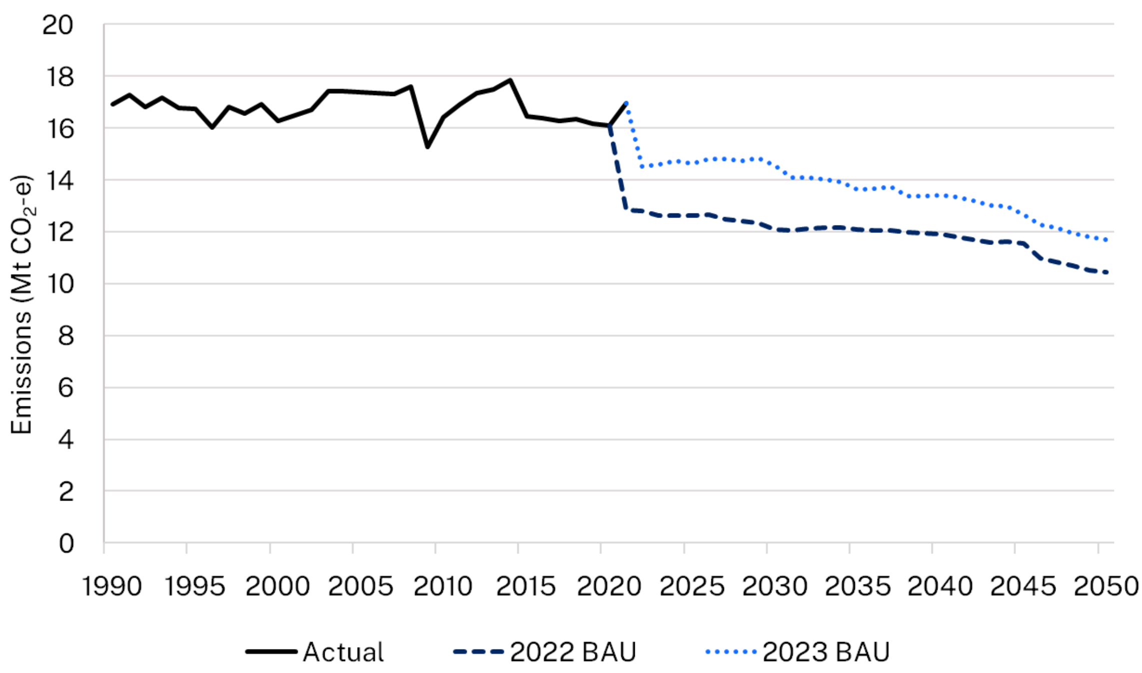

Figure 14 **Comparison of 2022 and updated 2023 business as usual (BAU) emissions projections for stationary energy**

The current policy projections have 2.7 to 3.4 Mt more emissions in 2030 compared to the previous projections update, and 2.9 to 4.2 Mt more emissions in 2035 compared to the previous projections update. In 2030, 2.5 Mt of this increase comes from the higher BAU projection, as shown in Figure 14. At the higher end of the range, the increase is a result of NZIIP abatement being revised down.

Methodology and assumptions

Business as usual methodology and assumptions

Energy industries (coal, gas)

Coal mining

Detailed greenhouse gas (GHG) emissions data was obtained from the Clean Energy Regular for each coal mine in New South Wales based on facility reporting under NGERS. This included emissions from onsite consumption of liquid and gaseous fuels and oils and greases.

For all new greenfield projects and brownfield extensions, data was based on information from published environmental impact statements (EIS). All reported liquid fuel consumption emissions for stationary (which includes non-road fuel consumption) and mobile activities were lumped together. The liquid fuel emissions were split between stationary and mobile sources based on previous NGERS facility data if the mine was an extension project, or based on comparable existing mines for new projects, distinguishing between underground and open-cut mining operations.

An emission intensity was developed for each mine based on the 2021–22 NGERS emissions data for stationary and mobile combustion and mine-specific run-of-mine (ROM) coal production data from Coal Services Pty Ltd (Coal Services 2023). Emissions were projected forward using these mine-specific emission intensities as a constant multiplied by the changing ROM coal tonnages out to 2050, as forecast for each mine by the Mining, Exploration and Geoscience (MEG) group within the Department of Regional NSW.

Coal production is projected to 2050 using MEG's 'likely' ROM coal production forecasts (June 2023). Sensitivity testing is conducted based on assumptions regarding potential minimum and maximum coal production scenarios. The 'likely' coal production scenario includes forecasts based on current mine approval dates as well as intended extensions beyond current approval dates, as indicated by operators in consultation with the MEG group. The minimum coal production scenario is based on current mine approval dates and possible closures before approval dates, as indicated by operators in consultation with the MEG group. The maximum coal production scenario is based on the 'most likely' scenario but also includes strategic release areas.

The following changes were made for the latest updated to the 2023 projections:

- Dartbrook is projected to operate between 2022 and 2023 and 2026 and 2027 and return to decommissioning thereafter.
- Myuna is projected to operate until 2031–32 rather than 2029–30.
- Fugitive emissions and ROM production forecasts for the Hunter Valley Operations Continuation Project were updated based on their recent modification application.
- The ROM production forecast for Boggabri was updated based on their 'Modification 8' EIS, which scales back production to 2034–35.
- Mt Thorley Warkworth operations are projected to continue to 2036–37 (and not beyond 2050).
- Dendrobium is projected to operate to 2029–30.
- Based on consultation with company representatives, Narrabri will continue their south extension operations to 2043–44 and the Gorman North area was removed from the most likely projection given uncertainties associated with this extension.
- The ROM production forecast for Moolarben Open Cut Modification OC3 is included in the projection for Moolarben Open Cut.
- Production at Stratford was scaled back to 2023–24 from 2039–40, due to announced closure.

Gorman North remains the only strategic release area but is only included in MEG group's 'maximum' coal production scenario.

Gas production, processing and distribution

Detailed GHG emissions data was obtained from the Clean Energy Regulator for each gas facility in New South Wales based on facility reporting under NGERS. This included stationary combustion emissions from gas production and processing plants, gas transmission and gas supply networks.

For large gas pipelines such the Moomba to Sydney and the Eastern Gas Pipeline where there is inline compression, an emission intensity was calculated based on the latest NGERS emissions data for stationary gaseous and liquid combustion and pipeline gas throughput (in petajoules per annum, PJ p.a.). The projected emissions were calculated based on the future throughput of the pipeline.

The projections included the 2 new developments, Port Kembla Gas Terminal (PKGT) and Narrabri Gas Project (NGP), which were assumed to commence operations in 2023 and 2026, respectively. The commencement of the NGP has been delayed by one year, confirmed through consultation with Santos. Data for these 2 projects were obtained from the EIS, available in the public domain (DPE 2022d). The EIS stationary energy emissions data were based on a maximum gas production scenario.

The main gas production forecasts (in PJ p.a.) for the NGP and PKGT were based on the Australian Energy Market Operator's (AEMO) *2021 Gas statement of opportunities* (GSOO) central case (scenario 1) (AEMO 2021). The *2022 Gas statement of opportunities* (AEMO 2022b) and *2023 Gas statement of opportunities* (AEMO 2023) did not include a central estimate, but a comparison of 2021 versus 2022 residential/commercial low gas price consumption forecasts showed that the 2022 forecasts were on average 3% lower. As it was unclear how this change would affect the stationary energy emissions from the gas projects, the production forecasts were held at 2021 levels.

To estimate future stationary energy emissions for the NGP, the BAU assumed that onsite power demand would be met by importing grid electricity. The NSW electricity grid will become increasingly decarbonised in accordance with the NSW Electricity Infrastructure Roadmap, providing further abatement for the project. This assumption has been confirmed by the project proponent. The forecast emissions were scaled according to the fraction of production in a given year compared to maximum production. The same approach was taken for stationary energy emissions for the PKGT.

Manufacturing industries and construction

Abatement assumed to occur as a result of firm corporate commitments and federally funded emissions reduction projects is included in the BAU scenario. BAU emissions projections have been substantially refined from the previous year's projections as follows:

- integrated the latest NGERS data, EIS information for new projects and commodity forecasts
- incorporated sectoral efficiency and productivity improvements rather than assuming the emission intensity of future production will remain constant for a given facility.

Where carbon reduction commitments are made for facilities covered under the Safeguard Mechanism, potential onsite abatement actions to reduce emissions are counted under the expanded current policy projection. When considering publicly stated corporate commitments, only site-specific reduction actions are considered. Similarly, abatement achieved through NSW Government funded projects are excluded from the BAU.

Projections approach: Bottom-up model

Facility-specific projections are developed for industries in New South Wales with facility-level production data, with the facility-level emissions data then aggregated to sector level. In addition to NGERS data, data was obtained from the Australian Energy Statistics (AES, Cth DCCEEW 2023i) to cross-check agreement with the data reported within the NSW Greenhouse Gas Inventory for specific sectors.

Emissions are calculated according to the formula:

$$E_t = E_{t-1}\ \Delta production$$

where:

E_t = emissions in year t (tonnes CO_2-e)

E_{t-1} = emissions in the previous year

$\Delta production$ = percentage change in production between year t and year t–1.

Projections approach: Top-down model

Application of the top-down model depends on the emission source and the availability of data. It is assumed that changes in sector emissions are proportional to changes in production, which are in turn proportional to changes in sector revenue. As the forecasts apply to Australia as a whole, it is assumed that each facility in a specific industrial sector in New South Wales will be affected equally.

The approach uses revenue forecasts to 2026 for each commodity or sector from market analyst reports from IBISWorld (IBISWorld 2022). This is currently the best available proxy for estimating the percentage change in production activities in each of the Intergovernmental Panel on Climate Change (IPCC) industrial subsectors. The IBISWorld revenue projections are Australia-wide and are assumed to hold equally for each state and each facility within a state. As better proxies become available, they will be incorporated in future projections.

The annual sector-level emissions are then projected forward in accordance with changes in sector revenue forecasts to 2026. For future emissions to 2050, a linear trend was assumed starting with the 2026 emissions.

The following changes were made in this latest update projections:

- 2023 Office of the Chief Economist *Resources and Energy Quarterly* (OCE REQ) forecasts for steel and aluminium production were updated, with lower compound annual growth rates for 2029–2050.
- In the iron and steel subsection, MolyCop Waratah (formerly Commonwealth Steel Waratah) is excluded from 2025 due to its announced closure in February 2024.
- The emissions projection for Qenos was updated. Qenos's polyethylene production data was not reported in NGERS, therefore a proxy was used based on ethylene feedstock produced. (Note that at the time of development of these projections, the closure of Qenos' Botany facility had not been announced).

- Boral's corporate abatement was updated to include its commitment to fuel switching.
- Manildra's corporate abatement was updated to include its commitment to fuel switching at the Shoalhaven starch facility.

Iron and steel

This subsection covers stationary energy emissions from fuel consumed by the production process, and coke oven gas (COG) related emissions. Ongoing steel production from BlueScope Port Kembla and InfraBuild Steel Mill Sydney is considered within the iron and steel stationary energy subsector. MolyCop Waratah is excluded from 2024–25 due to its announced closure in February 2024.

Emissions from the consumption of COG are not captured under NGERS but the energy consumption is. COG emissions are derived using facility energy consumption data for COG and an emission factor of 37.08 kg CO_2-e/gigajoule (GJ) (Cth DCCEEW 2023j). Only BlueScope Port Kembla uses COG; therefore, BlueScope Port Kembla is selected as the representative facility for modelling the main scenario.

The Office of the Chief Economist (OCE) projection scenario (for 2023–2028) and domestic growth scenario (using the OCE compound annual growth rate (CAGR) for 2029–2050) are selected as the BAU main scenario. The main scenario for steel production is identical to that assumed for industrial processes and product use (IPPU) related iron and steel emissions. The current GHG emission intensity for 2022 is assumed as a constant until 2050.

For 2023–2028, data from the OCE September 2023 *Resources and Energy Quarterly* (REQ) forecast (DISR 2023a) and March 2023 REQ forecast (DISR 2023b) (covering 2026–2028) are used to project iron and steel production in New South Wales, as shown in Table 6.

Table 6 Office of the Chief Economist forecasts for iron and steel as a percentage change in production (2023–2028)

2023	2024	2025	2026	2027	2028
−2.59%	2.66%	0.00%	0.00%	0.05%	0.31%

From 2029 to 2050, a domestic growth scenario is assumed with new production expansion continuing. The steel production growth rate is assumed to be equal to the OCE CAGR of 0.1%, as stated in the OCE REQ March 2023 forecast (DISR 2023b).

BlueScope's commitments for onsite abatement are outlined in Table 7, based on detail provided in the Greenhouse Gas Report of BlueScope Steel's Blast Furnace No. 6 Reline Project EIS (BlueScope 2022a, Appendix J).

Table 7 **Abatement assumed based on BlueScope Steel's published emissions reduction commitments (BlueScope 2022a)**

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
Dual lance tuyeres	2027–2050	Offsetting external metallurgical coal purchases. COG injection has the potential to reduce emissions by approximately 150,000 t CO_2-e p.a.	Company commitment
Hot blast gas waste heat recovery	2027–2050	Potential reduction of approximately 11,000 t CO_2-e p.a.; enables injection of COG into the blast furnace	Company commitment
Alternative fuel (use of charcoal produced from forestry waste)	2035–2050	Total emissions reduction 5% p.a. (estimation)	Company commitment

Production of solid fuels

This subsection covers production of coke, coal tar and coal by-products such as liquefied aromatic hydrocarbons. In New South Wales this is largely coke production related to iron and steel. NGERS does not capture emissions from the production of solid fuels, therefore, emissions projections were based on historical data from the State and Territory Greenhouse Gas Inventory (STGGI) and projected forward using the iron and steel production projections as a proxy (described in the previous section).

Non-ferrous metals

The major emission source in this subsector is from aluminium production. The emissions projections are based on the percentage change in output from the Tomago Aluminium facility. For 2023–2028, a combination of data from OCE REQ September 2023 (DISR 2023a) and OCE REQ March 2023 (DISR 2023b) were used to forecast aluminium production in New South, as shown in Table 8.

Table 8 **Office of the Chief Economist forecasts for aluminium percentage change in production (2023–2028)**

2023	2024	2025	2026	2027	2028
−0.07%	2.24%	0.08%	−0.72%	0.04%	−0.03%

For 2029–2050, the domestic growth scenario (OCE CAGR) assumes that new production expansion will continue. The aluminium production growth rate is assumed to be equal to the OCE CAGR of 0.4% for 2023–2028, as stated in the OCE REQ March 2023 forecast (DISR 2023b).

Similar to the IPPU aluminium production emissions projections, the main BAU scenario takes the OCE projections (2023–2028) and the domestic growth scenario projections (2029–2050). The 2022 GHG emission intensity is assumed to be constant out to 2050.

NGERS emissions for the non-ferrous metals subsector account for only 50–60% of the STGGI emissions (Cth DCCEEW 2023d). This may either be due to residual emissions from entities whose emissions fall below the NGERS reporting threshold, or an over-estimation of the quantity of 'other petroleum products' reported under the AES. A review of entities reporting under the National Pollutant Inventory (NPI) resulted in the identification of only one further facility not included in the NGER data under Australian and New Zealand Standard Industrial Classification codes 213 and 214. Therefore, it is concluded that the STGGI emissions for non-ferrous metals may be overestimated. A review of the NSW EPA environment protection licence (EPL) list also revealed no other facilities for this subsector.

NGERS data are therefore used as the basis for the projections over 2022–2050, which is responsible for a drop in emissions in 2022 (rather than any assumed abatement). The source of the discrepancy will continue to be investigated.

No abatement commitments have been identified in the non-ferrous metals subsector.

Chemicals

This subsection is disaggregated to facility level and includes emissions due to ammonia and nitric acid production, polymer production, with the remaining facilities grouped as other chemical manufacturing. Discrepancies between NGERS and STGGI emissions are also explored.

Historical emissions were collected from NGERS facility data. A cross-check against the STGGI for chemicals revealed a large gap in emissions when compared to the aggregated facility emissions data from NGERS. The gap could not be explained by comparison with the AES data for the sector. One plausible explanation is discussed in the polymer production subsection below.

Chemicals – ammonia and nitric acid production

The NGERS stationary energy emissions for Orica Kooragang Island are given for ammonia and nitric acid production. The emissions associated with the production of both commodities are summed to derive a total emission intensity. The BAU emission scenario is based on the percentage change in output from the Orica Kooragang Island facility. The current GHG emission intensity for 2022 is assumed constant to 2050.

For ammonia, the BAU scenario is identical to that used for the IPPU – chemicals industry – ammonia production. A domestic growth scenario is selected as the main BAU scenario.

Domestic growth scenario – ammonia

It is assumed that ammonia production will grow linearly from ~0.330 Mt p.a. in 2022 to 0.385 Mt p.a. in 2030. Production is capped at 0.385 Mt p.a. from 2030. This projection is based on information that Orica provided for its ammonia plant expansion project to increase production capacity to 0.385 Mt p.a. (Orica 2022a).

For nitric acid, the BAU scenario is identical to that used for the IPPU – chemicals industry – nitric acid production. A domestic growth scenario is selected as the main BAU scenario.

Domestic growth scenario – nitric acid

For the period 2022–2031, Australia's 2020 chemical industry emissions projections (DISER 2020a) are used as a proxy for growth, shown in Table 9, rather than the more recent 2023 projections (Cth DCCEEW 2023g). The year 2020 is used because the more recent emissions projections included emissions reduction projects for stationary energy. The 2020 projections are a better proxy for growth (without the influence of emission reduction) and consistent with the IPPU sector emissions for nitric acid (which does not include the same emission reduction projects).

For the period 2032–2050, published information from Orica describes an additional nitric acid plant that will be operating in 2031. The production of nitric acid will grow linearly to reach 0.605 Mt p.a. in 2051. The maximum capacity is 0.605 Mt p.a. following the expansion (Orica 2022a). Orica's commitments for onsite abatement are outlined in Table 10.

Table 9 Australian Government forecasts for chemical industry, percentage change in production (2023–2031)

2023	2024	2025	2026	2027	2028	2029	2030	2031
2.4%	1.0%	0.4%	0.5%	0.9%	0.9%	0.9%	0.4%	0.5%

Table 10 Abatement assumed based on Orica's emissions reduction commitments (Orica 2023)

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
Energy efficiency, electrification of energy consumption and heat recovery	2027–2050	Assumed to reduce 6,000 t CO_2-e p.a. (Orica's presentation in 2023)	Company commitment
Medium- to long-term sourcing of advanced biofuels, other low carbon fuels	2030–2050	Assumed to reduce 50,000 t CO_2-e p.a. from fuel switch	Company commitment

Orica's nitric acid projection is scaled up against the total nitric acid production, to include the additional emissions from the Thales group.

Chemicals – polymer production

A BAU emissions scenario has been considered, based on the percentage change in output from the Qenos Botany Bay facility. This plant processes ethane feedstock sourced from the Cooper Basin in South Australia into approximately 250 kilotonnes (kt) of ethylene p.a. for 2 downstream polyethylene plants producing low-density polyethylene and linear low-density polyethylene (Qenos 2022a). It is assumed that the current capacity is 210 kilotonnes (kt) of polyethylene p.a. (Qenos 2022b).

Qenos's polyethylene production data is not reported in NGERS, therefore assumptions are made based on ethylene feedstock produced. It is assumed that for 2023–2050, production is based on the growth rates for ethane steam cracking (BNEF 2021a; BNEF 2021a).

Qenos's commitments for onsite abatement are outlined in Table 11.

Table 11 Abatement assumed based on published commitments (Qenos 2022c)

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
Alternative fuel (e.g. hydrogen)	2030–2050	Assumed to reduce 85,000 t CO_2-e p.a. Assumed 50% of the coal consumption is replaced by renewable fuel	Company commitment (Qenos 2022c)

Chemicals – other chemical manufacturing

Other chemical manufacturing represents a small portion of emissions in this sector. The emissions projection is forecast based on the 2020 Australian emissions projections (DISER 2020a). For 2022–2030, the 2020 emissions projections for the chemical industry are used (DISER 2020a) and for 2031–2050, a CAGR of 0.5% is assumed.

Chemicals – discrepancy between NGERS and STGGI

NGERS emissions for the chemicals sector account for only about 40% of STGGI (Cth DCCEEW 2023d) total emissions. This may be due to residual emissions from a large number of facilities whose emissions fall below the NGERS facility reporting threshold. This was investigated by considering facilities that report under the NPI and NSW EPA EPL licence holders. Several smaller chemical manufacturing facilities were identified that are not included under the NGERS, however, these facilities are not of sufficient capacity to account for the 1.2–1.3 Mt CO_2-e difference between NGERS and STGGI emissions totals.

The chemicals sector includes emissions from the consumption of a complex mix of energy commodities including coal, natural gas, diesel oil, ethane, ethylene, naphtha, liquid petroleum gas, and other petroleum and petrochemical products. It may be possible to validate the NGERS data for each fuel type against detailed energy consumption data in the AES, but such data are confidential and could not be obtained to inform this analysis. A complicating factor when comparing NGERS and AES fuel consumption data is that about 25 PJ per year of energy consumption at one large facility is attributed to other petroleum products (including ethane, ethylene, naphtha, diesel oil and other petrochemicals). This lumped consumption figure in the NGERS makes verification against individual fuels in the AES difficult.

Another possible reason for the discrepancy is that for some activities (e.g. carbon black manufacture) significant quantities of fossil fuel feedstock is used as a source of carbon, however, relatively little is combusted (DISER 2022b). In NGERS, it is possible that a proportion of fossil fuels (especially ethane) have been counted as fossil fuel feedstocks. The accounting of fossil fuels as a feedstock instead of a fuel that is combusted may lead to the gap between reported NGERS and STGGI emissions for chemicals.

At this stage, the reason for the discrepancy is not clear. Therefore, the NGERS data are used as the basis for the projections from 2022 to 2050. This accounts for the drop in emissions from this subsector from 2021 to 2022, rather than any assumed abatement. The source of the discrepancy will continue to be investigated.

Non-metal minerals

This sector covers glass and glass products, ceramics, cement, lime, plaster and concrete product, and other non-metallic minerals. The emissions for glass and glass products, ceramics were forecast using IBISWorld revenue forecast data averaged over the above subsectors (IBISWorld 2022). After 2026, a linear regression was applied to extend the projection to 2050. The changes in production in these subsectors to 2026 are shown in Table 12.

Table 12 **IBISWorld revenue forecast data for non-metal minerals, percentage change (2023–2026)**

	2023	2024	2025	2026
Glass production	1.5%	2.9%	2.5%	2.2%
Ceramics	5.7%	1.5%	0.2%	2.5%

Emissions for cement, lime plaster and concrete product were forecast using cement production forecasts for Australia as a proxy (BNEF 2021a,b), assuming changes in sector emissions are proportional to changes in production. For other non-metallic minerals production, emissions are a fixed value over time as only one relatively small facility in New South Wales produces other non-metallic minerals (based on data provided by NGERS). Boral's commitments for onsite abatement are outlined in Table 13.

Table 13 **Abatement assumed based on published commitments (Boral 2022b)**

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
Alternative fuel – Berrima kiln chloride bypass	2023–2050	Assumed to reduce ~50,000 to 150,000 t CO_2-e p.a. Chloride bypass to increase use of alternative fuels from current 15% to 30% by the end of FY 2023, and proposed to 60% by FY 2025 (Boral 2022b)	NSW Major Resource Recovery Infrastructure grant $4.6 million (DPE 2022f)

Pulp, paper and print

The emissions for pulp, paper and paperboard manufacturing were forecast using IBISWorld revenue data as a proxy (IBISWorld 2022), shown in Table 14. Emissions projections were calculated using the same methodology as the non-metal minerals subsector.

Table 14 **IBISWorld revenue forecast data for pulp, paper and print, percentage change (2023–2026)**

	2023	2024	2025	2026
Pulp, paper and print	−2.2%	0.9%	1.0%	−2.5%

Food processing, beverages and tobacco

Emissions were forecast using the IBISWorld revenue growth rates taking the average of beer, wine, fruit and vegetable and meat processing as a proxy for the sector (IBISWorld 2022), shown in Table 15. Emissions projections were calculated using the same methodology as the non-metal minerals subsector. Manildra's commitments for onsite abatement are outlined in Table 16.

Table 15 IBISWorld revenue forecast data for food processing, beverages and tobacco (2023–2026)

	2023	2024	2025	2026
Food processing, beverages and tobacco	1.58%	0.41%	0.9%	1.22%

Table 16 Abatement assumed based on published commitments

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
Alternative fuel – Manildra Shoalhaven starch site co-generators	2024–2050	Assumed to reduce 100,000 t CO_2-e p.a. from the gas co-generator to replace coal (ERM 2023)	Company commitment (Manildra 2022)

Other manufacturing sectors

Emissions were forecast using IBISWorld revenue growth rates, using an average of steel pipe/tube manufacturing and structural steel fabricating growth rates, as shown in Table 17 (IBISWorld 2022).

Table 17 IBISWorld revenue forecast data for other manufacturing, percentage change

	2023	2024	2025	2026
Other manufacturing	0.92%	1.50%	0.57%	1.54%

For construction, growth forecasts were based on the Low Emissions Building Materials Program's forecast for 2022–2050 (all materials for building and infrastructure construction). The program's growth forecast models consider interventions undertaken in the program, grouped by the streams of work within the program in June 2021 and are shown in Table 18.

Table 18 Low Emissions Building Materials Program growth forecast for construction, percentage change (2023–2026)

	2023	2024	2025	2026
Construction	−0.06%	2.87%	5.04%	−0.13%

For other metal mining such as silver, lead and zinc, IBISWorld revenue growth rates for silver, lead and zinc ore mining were used as a proxy (IBISWorld 2022), shown in Table 19.

Table 19 **IBISWorld revenue forecast data for other metal mining, percentage change (2023–2026)**

	2023	2024	2025	2026
Other metal mining	1.35%	2.51%	1.22%	1.03%

For textiles, the IBISWorld revenue growth rates for synthetic and natural textile manufacturing were used (IBISWorld 2022), as shown in Table 20.

Table 20 **IBISWorld revenue forecast data for textiles, percentage change (2023–2026)**

	2023	2024	2025	2026
Textiles	−0.13%	−0.29%	−0.51%	−0.32%

As discussed previously for the chemicals subsector, NGERS emissions data for this subsector accounts for 40% or less of the STGGI (Cth DCCEEW 2023d) emissions. The source of the discrepancy was investigated, and the conclusion was that the STGGI emissions for these sectors may be overestimated. For projections, the construction, textiles and other manufacturing subsector emissions were lumped as ‘Other’ under ‘Manufacturing industries and construction’. The NGERS data for ‘Other’ was used as the basis for the projections from 2022 to 2050, which is responsible for a drop in emissions in 2022 (rather than any assumed abatement). The source of the discrepancy will continue to be investigated.

Other sectors

Other sectors contributing to stationary energy emissions include primary industries (agriculture, forestry, fishing) and commercial/institutional and residential sectors. These sectors accounted for total emissions of about 6 Mt CO_2-e in 2021, making up about 30% of total NSW stationary energy (excluding electricity generation) emissions, with emissions in the residential, commercial and institutional sectors accounting for about 64% of these ‘other sector’ emissions. Emissions from buildings are primarily driven by gas use in residential and commercial buildings.

Higher emissions were projected for this subsector due to higher emissions reported in 2021 STGGI (Cth DCCEEW 2023d). BAU projections for energy use (primarily diesel) within primary industry (agriculture, forestry, fishing) were based on the NSW contribution to national emissions for this subsector (Cth DCCEEW 2023d) and Australia’s emissions projections to 2035 (Cth DCCEEW 2023g), with linear forecasts for post-2035 emissions. For agriculture, forestry and fishing it is assumed that there is a 0.5% increase p.a. for post-2035 emissions (Cth DCCEEW 2022a).

Current policy assumptions

As described previously, abatement in this sector is projected to come from fuel switching and electrification, supported by net zero programs and related policies including.

For NZIIP, emission reductions in the abatement as originally designed scenario are based on the original targets outlined in the program's design. For the more cautious 'abatement as currently tracking' scenario, abatement under the program is assumed to 2030, based on preliminary analysis of what is achievable from existing or likely near-term funded projects. The 2030 abatement for stationary energy in high emitting industries is approximately 50% lower for the more cautious 'abatement as currently tracking' scenario, with no abatement assumed beyond 2030. The program is currently being reviewed and future updates to the projections will incorporate revised abatement projections for the program, including interaction with the Safeguard Mechanism.

Updated abatement projections for the Safeguard Acceleration Program are reported as part of the Energy Savings Scheme, calculated based on the energy savings in the scheme's implementation data from the former Independent Pricing and Regulatory Tribunal. Emission reductions are assigned to the commercial/residential sectors. The Sustainable Government, Sustainable Council, Sustainable Advantage continue to support emissions reductions within commercial/institutional sectors, with abatement projections unchanged from original program design.

GHG emissions reductions in the commercial and institutional building sectors due to reduced gas consumption are also supported by the Accelerating Net Zero Buildings Initiative and the Sustainable Buildings SEPP (NSW Government 2022e) and the NSW Government's BASIX program. The Sustainable Building SEPP sets sustainability standards for residential and non-residential development, aims to reduce GHG emissions from energy use, establishes processes for monitoring embodied emissions of building materials, and requires new buildings to be net zero ready by 2035. No gas or diesel is assumed in new building from 2035 onwards.

Actions under the *NSW Hydrogen Strategy* (DPIE 2021f) and supply chain benefits arising from the *NSW Electric Vehicle Strategy* (NSW Government 2021) are likely to indirectly support pathways for hydrogen-fuelled vehicles and battery electric vehicles and equipment replacing diesel-powered non-road vehicles and equipment at mine and manufacturing sites.

Open-cut mines operating post-2042 are assumed to replace non-road diesel equipment with clean technology starting in 2032. The abatement to be achieved post-2030 by replacing diesel-powered mobile plant and equipment was modelled on a mine-by-mine basis accounting for the extent of emissions projected for the mine and the forecast remaining mine life.

Fuel switching and energy efficiency measures within NSW industry were assumed as part of a broader market impact, including a 25% reduction in energy use from gas and diesel by 2030 and reaching 60% by 2050. Activities are likely to include implementation of solar thermal and biogas process heating, upgrading and electrification of process heating, production process improvements, boiler replacements and waste heat recovery.

A recent study identified available and cost-effective measures to reduce diesel consumption from agriculture in New South Wales in the near term by about 10% for mobile applications and by about 25% for stationary energy (Gjerek et al. 2021), also included as a broader market impact. Opportunities are likely to include replacing diesel pumps with solar photovoltaic powered electric pumps or electrification (grid), and energy efficiency improvements through optimal speed control.

Fuel switching and energy saving opportunities within the commercial, institutional and residential sectors were also considered with increased uptake anticipated to leverage the expanded Energy Savings Scheme, representing a broader market impact beyond direct emissions reductions under the Business Decarbonisation and Safeguard Acceleration programs. This included an assumed 15% reduction by 2030 and 30% by 2050.

Considerations for projection updates

Future projections updates will continue to incorporate the latest available data, including NGERS data and the latest commodity forecasts. Potential market impacts of the European Union Carbon Border Adjustment Mechanism and the implications of growing corporate carbon reduction commitments will continue to be considered. A future goal is also to develop more resolved, bottom-up modelling of building-related emissions.

It is expected that the NSW EPA CCPAP, the reform of the Safeguard Mechanism and NZIIP will all support the adoption of abatement technologies across industrial sectors. Further work is needed to understand how these related policies will interact, help drive onsite abatement and be counted for future projections updates.

Transport

Emissions in the transport sector result from the combustion of fuels for transportation and include emissions from road transport, domestic aviation, railways, domestic waterborne navigation and other transport sources (pipeline transport, off-road). Emissions from the generation of electricity used by electric vehicles (EVs) and rail are accounted for in the electricity sector. More detailed emissions projections were undertaken for road transport due to the more significant contribution of this sector. Road transport accounted for 91% of NSW transport emissions in 2021, with domestic aviation (3%), railways (3%), waterborne navigation (2%) and other transport sources (0.3%) being more minor sources.

Summary of the emissions trends

Business as usual

Inventoried emissions (1990–2021) and business as usual (BAU) emissions projections (2022–2050) for the NSW transport sector are shown in Figure 15. Transport emissions have increased year-on-year since 1990, with pre-COVID-19 emissions almost 50% higher than in 1990. Road transport currently accounts for over 90% of transport sector emissions with light vehicles accounting for about 67% and the balance coming primarily from road freight. Future transport emissions are projected to be reduced due to ongoing COVID-19 impacts on travel behaviour, lower population growth compared to pre-COVID-19, and due to the market-driven uptake of EVs particularly within the light vehicle fleet. By 2050, BAU transport emissions are projected to be of a similar order to 1990 levels with the percentage share of light vehicle emissions projected to reduce. Freight and aviation emissions continue to increase in the 2030s and 2040s under BAU.

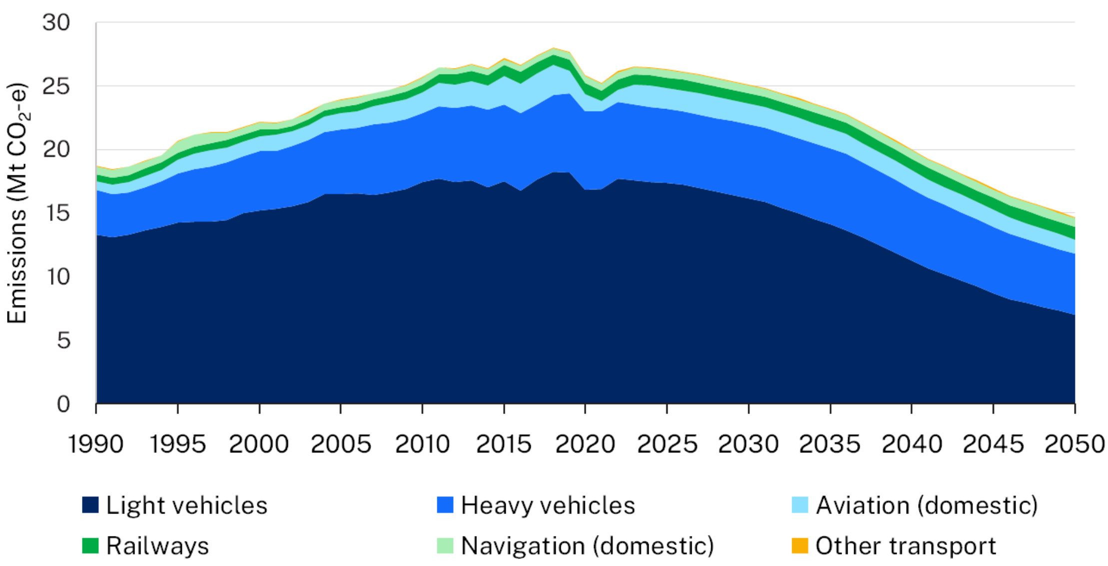

Figure 15 **Transport emissions by subsector showing inventory estimates (1990–2021) and business as usual emissions projections (2022–2050)**

Current policy

Abatement in this sector is projected to come from:

- accelerated update of EVs as a result of the *NSW Electric Vehicle Strategy* (NSW Government 2021)
- transition of buses powered by diesel and compressed natural gas under the *Zero Emission Bus Transition Strategy* (TfNSW 2022a)
- abatement in the heavy vehicle categories supported by the *Towards Net Zero Emissions: Freight Policy* (TfNSW 2023)
- abatement in the rail sector due to the adoption of bi-modal trains under the Regional Rail Project
- future action under stage 2 and 3 funding.

For this sector, no difference is currently identified between the abatement as originally designed scenario and the 'abatement as currently tracking' scenario, therefore a single current policy projection is presented. The integrated abatement that is projected to be achieved under current policy is shown in Figure 16.

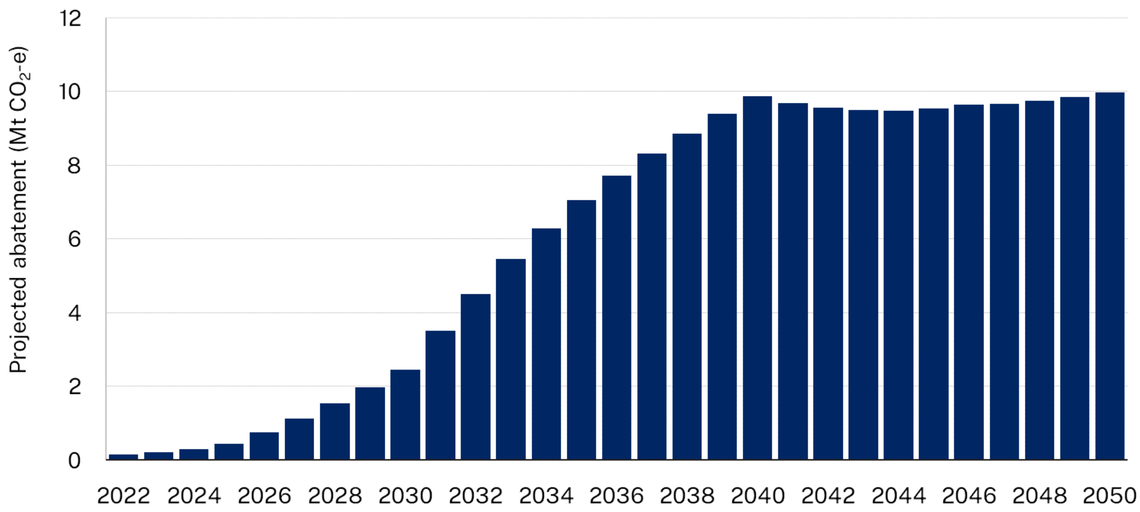

Figure 16 **Abatement of transport emissions projected to be achieved by Net Zero Plan stage 1 programs and related policies (2022–2050)**

The resultant current policy projection for this sector is presented in Figure 17. Emissions reductions continue to increase as the fleet turns over and the share of EVs and zero emission buses and trucks in the stock increases. Under current policies and future funding, annual transport emissions are projected to reduce by about 2.4 Mt CO_2-e by 2030, with reductions of around 7.1 Mt CO_2-e by 2035 and 9.9 Mt CO_2-e by 2040. With increasing decarbonisation of the electricity grid, the potential for indirect (scope 2) emissions from grid electricity consumption will reduce significantly, with reductions in direct scope 1 emissions far exceeding indirect emissions.

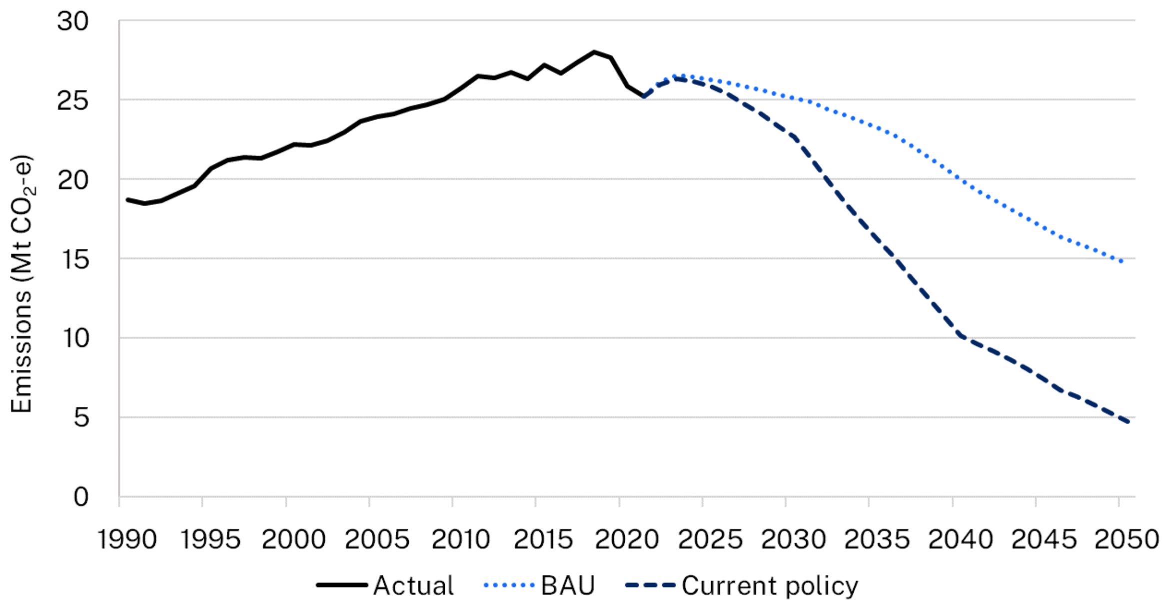

Figure 17 **NSW transport emissions as inventoried (1990–2021), with business as usual (BAU) and current policy emissions projection (2022–2050)**

Inventoried emissions (1990–2021) and current policy emissions projections (2022–2050) for the NSW transport subsectors are shown in Figure 18. Light vehicles are projected to reduce significantly in terms of absolute emissions and percentage share of transport sector emissions. Residual heavy-duty vehicles and aviation are projected to become the dominant source of remaining transport emissions in the 2040s.

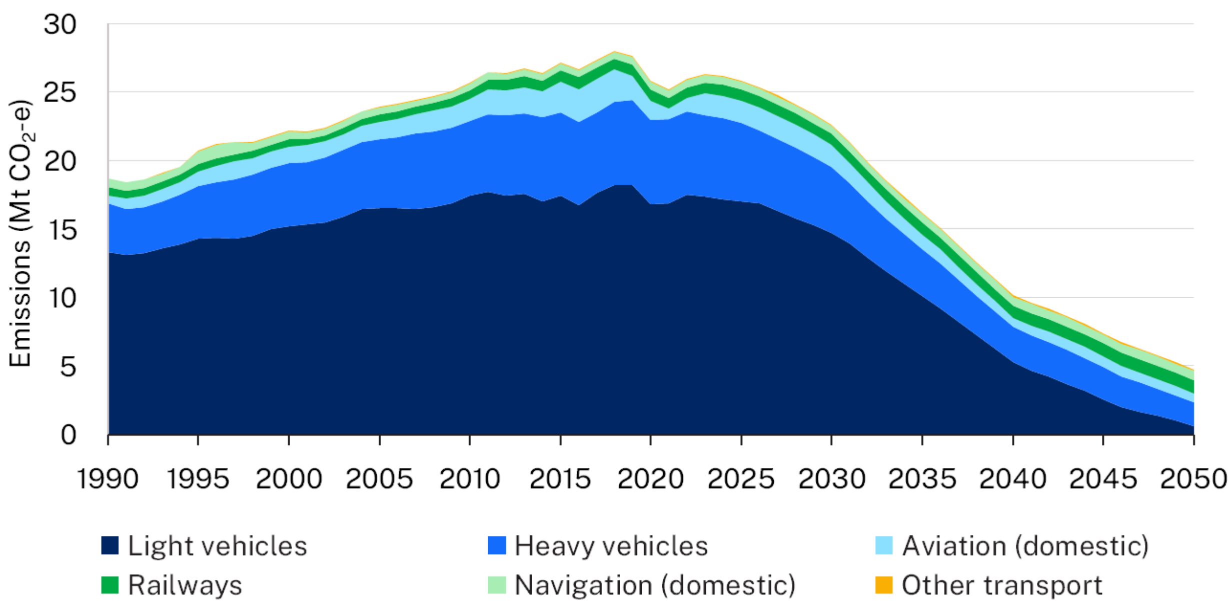

Figure 18 **Transport emissions by subsector showing inventory estimates (1990–2021) and current policy emissions projections (2022–2050)**

Summary of changes in emissions since last year's projection update

Transport emissions in the latest modelling are projected to be 1.0 Mt lower in 2030 and 1.4 Mt lower in 2035 compared to the previous projections update. The lower projected emissions across the transport sector are a result of higher abatement in road transport due to EV update and additional abatement in the heavy vehicle sector, as well as assumptions for sustainable aviation fuel uptake for commercial airlines. Further details on the assumptions are presented in subsequent sections.

Methodology and assumptions

Business as usual

Road transport

Light duty vehicles, including passenger cars, light commercial vehicles and motorbikes, contributed 73% of road transport emissions in 2021, with the remaining 27% due to heavy-duty vehicles (mainly trucks).

The department's NSW fleet and emissions models were applied to project emissions from light and heavy-duty vehicles using a state-aggregated modelling approach (Figure 19).

NSW fleet-aggregate emission factors were forecast by vehicle type for recent and future years, and applied together with vehicle kilometre travel (VKT) projections from transport modelling by Transport for New South Wales (TfNSW) to project future emissions.

An overview of the overall approach applied is as follows, with further detail on the department's fleet and emissions modelling provided below:

- Fleet modelling was used to project the future profile of the NSW light and heavy-duty vehicle fleets by estimating fleet growth, vehicle sales and vehicle attrition from a base year of NSW registration data.
- TfNSW provided VKT projections for light and heavy-duty vehicles, with transport model outputs spanning regional and metropolitan areas of the state, namely Strategic Transport Model and Freight Movement Model for the Greater Metropolitan Area, and the Regional Transport Model and Regional Freight Model for regional NSW. This included annual VKT by speed band and vehicle type (cars, light commercial vehicles, articulated and rigid trucks) and annual VKT for buses and coaches.
- Fuel consumption figures from the fleet model and VKT estimates were compared with benchmark sources for model validation. VKT estimates for recent years were compared to Australian Bureau of Statistics (ABS) *Survey of motor vehicle use* data (ABS 2020a), with VKT projections compared to the Australian Government Bureau of Infrastructure and Transport Research Economics VKT projections for New South

Wales (BITRE 2019). Calculated fuel consumption was compared to state-aggregate fuel use from the *Australian Petroleum Statistics*.

- Fleet-aggregate emission factors were derived using the department's vehicle emissions model and stock projections from the fleet model. Emission factors were derived by vehicle type and speed class, with greenhouse gas (GHG) emissions expressed as grams of CO_2-e per km travelled. Derivation of fleet-aggregate emission factors accounted for the impact of seasonal effects, cold start correction factors and VKT splits by fuel/motive power for each of the base vehicle types.
- Annual emissions were projected based on fleet-aggregate emission factors (g/km) applied with annual VKT projections. This was done by vehicle category and speed bin for each scenario and year, to estimate total emissions for modelled years.
- GHG estimates for a pre-COVID-19 base year (2019) were compared with road transport emissions published for the NSW Greenhouse Gas Inventory, and scaling factors derived and applied to approximate the inventory estimates.

The modelling accounted for:

- travel behaviour in future scenarios, including proposed transport infrastructure projects from the Greater Sydney Integrated Network Plan
- ongoing impacts of COVID-19 on land-use forecasts and work-from-home and peak spreading travel behaviour. This scenario incorporated the latest assumptions regarding travel behaviour post-COVID-19, with a lower rate of population growth (particularly in Sydney), aligned with the department's 2022 population update and reduced commuter travel due to higher rates of work-from-home and lower travel demand during morning and afternoon peaks.

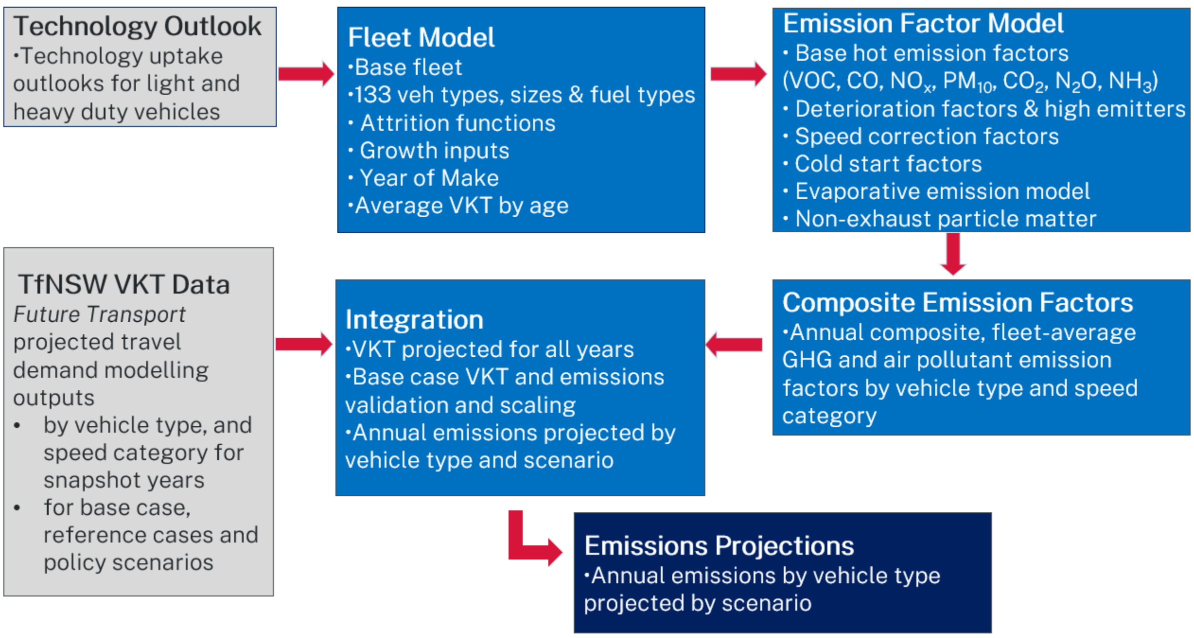

Figure 19 Fleet and emissions modelling applied for base case road transport projections

Fleet and emissions modelling

The NSW fleet and emissions models applied to project road transport emissions are based on models developed for NSW EPA air emissions inventories for the Greater Metropolitan Region (EPA 2012, 2019). These models were extended for NSW application and updated to incorporate the latest emission factors and vehicle sales trends.

The fleet model projects the future fleet profile by estimating fleet growth, vehicle sales and vehicle attrition from a base year of NSW registration data. Vehicle numbers for New South Wales for the base year of 2012 were taken from the ABS *Motor vehicle census* (ABS 2019). Within each light vehicle type (e.g. passenger cars, SUVs, light commercial vehicles), the *Motor vehicle census* data were apportioned into vehicle sizes based on a detailed analysis of the entire TfNSW registration database. The age profile was calculated to match the TfNSW registration data.

The light duty vehicle fleet model 2012 base year was projected forward to 30 June 2023 using year-on-year fleet growth from the ABS *Motor vehicle census* for passenger vehicles (including cars and SUVs) and light commercial vehicles, achieving close to identical total light duty vehicle stock numbers in 2023. The growth in passenger vehicle and light commercial vehicle numbers was apportioned into fuel types and the fleet model size categories based on detailed 'VFACTS' sales data (FCAI 2023) supplemented by TfNSW data on new registrations. The Federal Chamber of Automotive Industries publishes monthly and annual vehicle sales data in the VFACTS reports. The department purchases detailed VFACTS reports periodically to support fleet modelling.

Projected growth in the light duty vehicle fleet was estimated by fitting saturating curves to the trend of passenger vehicles and light commercial vehicles per capita and applying these relationships to the department's population projections (DPE 2022g). For each projection year, the number of vehicles leaving the fleet was estimated using attrition functions, and the annual sales estimated by adding the attrition numbers to the estimated growth in vehicle numbers for the year.

Annual vehicle sales by vehicle type were divided into fuel types (motive power) by applying a percentage of the sales figure. The base case uptakes of battery electric vehicles (BEVs) and plugin hybrid EVs were adopted from modelling by Veitch Lister Consulting as referenced in the *NSW Electric Vehicle Strategy* (NSW Government 2021). The sales share of hybrid vehicles was adopted from previous modelling done by the CSIRO for the Australian Government to inform the national GHG emissions projections (Graham et al. 2019). The balance of the projected annual sales was taken to be petrol and diesel in relative proportions fixed at the average observed in the VFACTS sales data for 2020–2023 (FCAI 2023).

Rigid and articulated fleet growth is estimated from historical growth in fleet numbers from the TfNSW registration database supplemented by the ABS *Motor vehicle census*. Detailed analysis by 30 heavy vehicle configurations (GVM/GCM and truck–trailer combination types by axle configuration) performed by the National Transport

Commission (in 2022) is used to establish historical trends of the total fleet disaggregated by fleet model size category.

The heavy-duty vehicle fleet is projected to 2020 from the base year of 2012 by applying the actual growth from the registration records, resulting in 2020 model fleet numbers matching the registration data. New truck sales are estimated from the difference between the growth of the fleet minus the annual attrition; although for heavy vehicles this is complicated by interstate transfer of vehicles and other unidentified factors contributing to erratic year-on-year trends in vehicle numbers by year of manufacture. To estimate future fleet growth a linear regression of historical growth against gross state product was performed, as logically the freight task would be expected to increase as economic activity increases.

The uptake rates of zero or low emission heavy vehicles, as a percentage of new vehicle sales, are estimated by consideration of projections from a range of sources (Graham and Havas 2021; Reedman et al. 2021; BNEF 2021b) and including uptake rates for hydrogen-fuelled trucks modelled for the *NSW Hydrogen Strategy*. Near-term NSW/Australian trends were also informed by current announced policy and original equipment manufacturer announcements regarding supply of low/zero emission trucks to Australia.

Zero emission vehicle uptake is allocated between the fleet model truck sizes considering the duty cycles (loads, trip distances and annual VKT) in relation to technology capability and information on the total cost of ownership of different technologies. It is assumed on this basis that hydrogen-fuel cell vehicles will be used in the near and medium term where BEVs are not suitable in terms of range and charging times for the heavier long-haul operations. Where published technology uptakes are projected as a percentage of the total fleet stock, sales shares were estimated iteratively to match the fleet percentages. For both rigid and articulated trucks, the small uptake of plugin hybrid EVs was adopted from Graham and Havas (2021), the hydrogen-fuel cell vehicles uptake modelled next, and the BEV uptake modelled last and capped to balance the total fleet technology sales shares to 100%.

The fleet model estimates VKT per vehicle as a function of age based on an analysis of 10 years of pooled data from the ABS *Survey of motor vehicle use* (ABS 2020a). Total fleet VKT was estimated for each vehicle and fuel type category by multiplying the number of vehicles of each year of manufacture by the corresponding annual VKT and summing over the years of manufacture.

The emissions model estimates the fleet-aggregate emission factors (g/km), allowing total emissions to be calculated by multiplying the VKT by vehicle type and fuel type by the emission factor. Emission factors derive from:

- the Australian *National in-service emissions study* (DEWHA 2009) study for petrol vehicle emissions up to ADR79/01 (Euro 3 and Euro 4 vehicles); the test drive cycles used were developed from extensive on-road tests in 5 Australian capital cities
- ADR79/02 (Euro 4) to ADR 79/04 (Euro 5) emissions and fuel consumption estimated by reference to the European *Air pollutant emission inventory guidebook*

2019 (EEA 2019), which is the basis of the COPERT model, and consideration of the historical Australian data

- diesel vehicle emission factors and fuel consumption based on limited Australian test data and the European guidebook/COPERT data (TER 2021)
- the Australian diesel national environment protection measure study, which tested pre-ADR70 and ADR70 rigid and articulated trucks
- the South Australian Test and Repair program, which tested pre-ADR70, ADR70 (~Euro I- II) and ADR80/00 (Euro II) trucks
- ADR80/02 (Euro IV) to ADR 80/04 (Euro VI) emissions and fuel consumption are estimated by reference to the European guidebook, which is the basis of the COPERT model, and consideration of the historical Australian data.

CO_2 emission and fuel consumption factors were extensively reviewed and revised by the department in 2021 to support road transport modelling.

New petrol and diesel vehicles entering the NSW fleet were assumed to be certified to Euro 5 (ADR79/04), and Euro 6 was assumed to be adopted from 2027. Hybrid vehicles and plugin hybrid EVs were assumed to consume 22–31% and 53–58% less fuel than equivalent internal combustion engine light vehicles, respectively. This was based on Green Vehicle Guide data for matching internal combustion engine and hybrid/plugin hybrid EV models and consideration of international studies on the difference between official test results and real-world fuel consumption (ICCT 2017, 2019; TNO 2018). Exhaust emissions are assumed to scale with fuel consumption.

Motorcycle emissions

Motorcycle emissions were projected to 2030 based on national emissions projections for this subsector multiplied by the ratio of NSW emissions to national emissions for each sector for the latest GHG inventory year (2021), with the 2022–2030 trend continued to 2050 (DISER 2020b, 2021a).

Domestic aviation

Domestic aviation refers to civil domestic passenger and freight traffic that departs and arrives in New South Wales, including take-offs and landings for these flight stages. The subsector includes all aircraft purchasing aviation fuel in New South Wales for domestic use, including:

- commercial domestic (passenger and freight) flights
- private and charter flights.

The following sources are dealt with elsewhere and are excluded from this subsector:

- fuel combustion associated with ground handling operations
- energy consumption associated with airport operations
- military fuel consumption at military airports.

Activity data

Data used in the projection of NSW domestic aviation emissions are listed in Table 21.

Table 21 Data referenced for projection of aviation emissions

Dataset	Description	Source
NSW population	NSW population projections based on common planning assumptions to 2060–61	DPE 2022g
Bureau of Infrastructure and Transport Research Economics airport traffic data	Domestic revenue passenger numbers by airport (1985–2022)	BITRE 2022a
Australian Petroleum Statistics	Sale of domestic and international aviation fuel in NSW (2010–11 to 2021–22)	DISER 2022a
NSW Greenhouse Gas Inventory	NSW domestic aviation emissions (1990–2021)	Cth DCCEEW 2023e
National Greenhouse and Energy Reporting Scheme facility-level reporting data	Kilolitre (kL) of fuel combusted in NSW and emissions for commercial aviation	Confidential data provided by the Clean Energy Regulator

Projections approach

Fuel used in aviation is disaggregated into commercial flights, charter flights and other private aircraft use. National Greenhouse and Energy Reporting Scheme (NGERS) data includes fuel (and emissions) for commercial and charter flights. The Australian Energy Statistics (AES) provide fuel consumption for all aviation (total jet fuel and aviation gasoline used in the sector). The AES also include fuel used for military use and this is therefore removed based on an assumption that 8.2% of jet fuel and 0.1% of avgas is assigned for military use (DISER 2022b).

When military fuel (reported elsewhere) is excluded, the AES fuel consumption is very similar to fuel consumption derived (back calculated) from the total aviation emissions reported under the State and Territory Greenhouse Gas Inventory (STGGI). Therefore, to normalise the sum of the total disaggregated emissions to STGGI emissions, the difference between the NGERS reported fuel consumption and the total estimated STGGI fuel consumption is assigned to other private aircraft use.

Disaggregation of emissions into the categories above allows emissions projections to be derived separately, using different growth assumptions where appropriate.

Domestic commercial aviation emissions were projected based on NSW population projections to 2050 and accounting for trends in domestic and regional revenue passenger movements relative to state population numbers over 1990–2022.

Domestic/regional passenger movements have increased at a faster rate than population due to people travelling more (movement/population of 1.1 in 1990 increasing to 3.8 in 2019). The COVID-19 pandemic has had a significant impact on domestic aviation in New South Wales, with an approximate 70% decrease in domestic passenger numbers from FY 2019 to FY 2021. The industry is recovering, with FY 2023 domestic passenger numbers in the state only marginally down on pre-COVID-19 levels (~12%) (calculated based on outbound domestic passenger movements in NSW airports; BITRE 2022a). The trend of increasing passenger movements is also recovering, with movements in FY 2023 returning to 3.4 movements per population.

The previous 2022 projections update assumed a COVID-19 recovery year of 2024 (for a return to 2019 passenger numbers), consistent with forecast used for the Waypoint 2050 analysis (ATAG 2021) and what the International Air Transport Association predicted (IATA 2022). These previous assumptions have proved on track for domestic travel in New South Wales, with FY 2023 domestic passenger movements being only 12% lower than 2019.

However, to account for the ongoing impacts of hybrid work practices and video conferencing, the assumed reduction in business air travel is retained from the previous projections update. Consistent with TfNSW modelling, we have applied a 25% reduction in business air travel from 2024, based on the assumption that corporate travellers comprise 12% of total passenger numbers (PwC n.d.). These assumptions will be continually reviewed in future updates. In summary, future passenger numbers for New South Wales are projected out to 2050, as follows:

- for 2024, passenger numbers recover to pre-COVID-19 (FY 2019) levels, however, an ongoing reduction of 25% in business travel is assumed
- for 2025–2050, the historical linear trend in growth (1990–2019) is continued.

The resultant trend is shown in Figure 20.

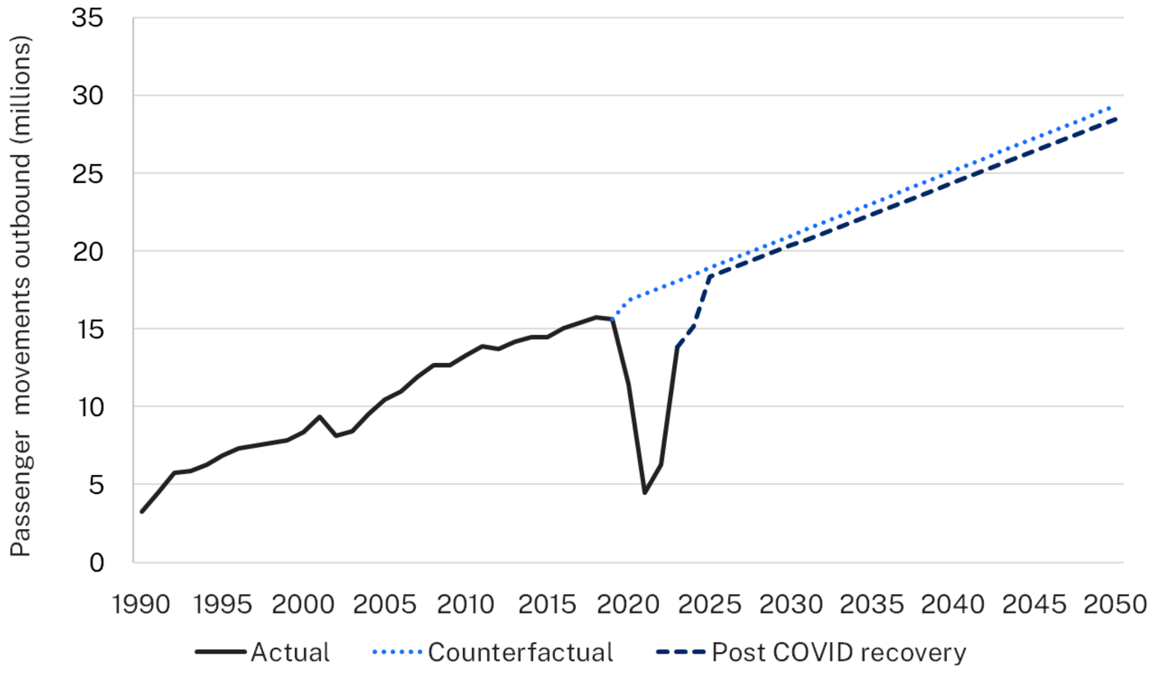

Figure 20 **Historical (1990–2023) and projected revenue passenger numbers (outbound) for New South Wales (2024–2050)**

On the basis of population projections and forecasts for passenger movements per capita, total domestic and regional passenger movements were projected to increase from about 31 million in 2019 to about 56 million in 2050 (down from the previously projected 58 million in our 2021 projections but up from the 53 million in our 2022 projections). Passenger movements projected were comparable to unconstrained domestic/regional passenger movements projected in the 2010 *Joint study on aviation capacity in the Sydney region* (Department of Infrastructure and Transport 2010), but comparable to projections within the *Sydney Airport master plan* (Sydney Airport 2019) for 2039, accounting for Western Sydney Airport Stage 1 passenger projections (Deloitte 2017).

Abatement assumptions in the base case

The International Air Transport Association's Fly Net Zero commitment requires member airlines to achieve net zero carbon by 2050, achieved through emissions reductions from efficiency improvements, sustainable aviation fuel (SAF), emerging technology (hydrogen, electric) and offsets (IATA 2021). Passed in October 2021, the commitment is not directly referenced by major airlines operating in New South Wales.

In March 2022, the Qantas Group released its *Climate action plan* (Qantas 2022), which commits to average fuel efficiency improvements of 1.5% per year from 2023 to 2030 (baselined to 2019) and investment in SAF to ensure 10% in the fuel mix by 2030 and 60% by 2050. Qantas have also reported an initiative to help kick start domestic SAF industry, including their representation on the Australian Government's Jet Zero Council and a joint investment of $300 million with Airbus to establish a SAF industry in Australia.

A market study of SAF prepared for the Department of Regional NSW (Deloitte 2023), modelled a low, medium and high scenario for domestic uptake of SAF in New South Wales. The assumptions in this study were based on the ReFuelEU Red Energy Directive commitments for SAF uptake, including a commencement year of 2025 (at 2%) and 5-yearly increments to reach a target of 63% by 2050. The Deloitte study assumed a 5-year lag on the European Union (EU) for commercial airlines in New South Wales and a 10-year lag on the EU for general aviation in the state. However, applying these assumptions falls short of the Qantas commitment for 10% by 2030. Therefore, for base case projections a commencing year of 2028 for SAF is assumed (at 2% of total fuel) for commercial airlines and a commencing year of 2033 for general aviation is assumed. For commercial airlines, this is equivalent to 7% SAF by 2030, 31% SAF by 2040 and 53% SAF by 2050. For the SAF that is used (blended at the percentages described above), the assumed emission reduction from SAF, compared with the equivalent amount of jet fuel, commences at 80% and increases to 95% by 2050.

Qantas fuel efficiency improvements are included in the BAU projections, while it is assumed that the International Air Transport Association fuel efficiency improvements of 3% below BAU by 2035 will be adopted by other commercial airlines in New South Wales (noting that the Qantas commitment goes beyond this commitment).

BAU projections do not account for technology shift towards electric propulsion or a revolutionary shift to zero emission aircraft (i.e. hydrogen).

In summary, BAU projections account for:

- population growth and associated growth in revenue passenger numbers
- Qantas's commitment for a 1.5% per year fuel efficiency improvement for 2023–2030 (with no further fuel efficiency beyond 2030)
- other commercial airlines complying with the International Air Transport Association fuel efficiency improvement commitment of a 3% improvement on BAU by 2035
- SAF starting to be being implemented by commercial airlines in 2028, starting at 2% and increasing in line with EU targets.

Projections for private, charter and other non-commercial flights were based on NSW population projections to 2050, with a linear increase in emissions assumed with population. No fuel efficiency assumptions are made for projections in private and charter flights, however, it is assumed that SAF will start to be being implemented by 2033.

A summary of the estimated emissions by category is presented in Figure 21.

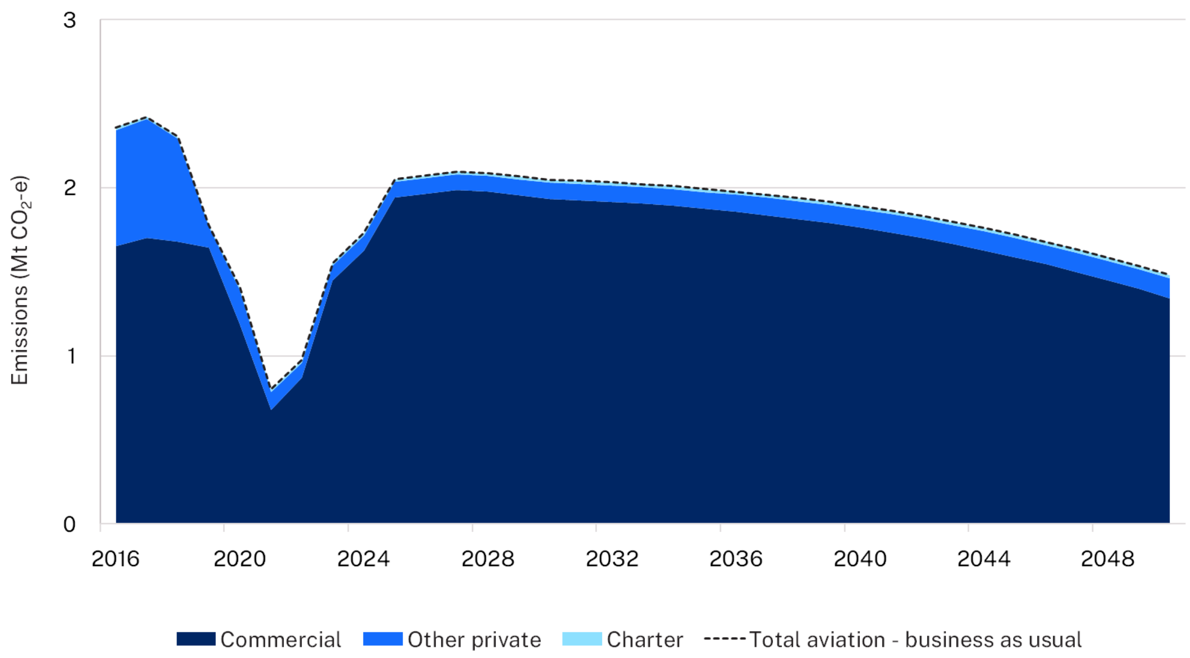

Figure 21 **Emission estimates for subcategories within the aviation subsector (2016–2050)**

Railways

The railway subsector includes scope 1 emissions associated with the transport of goods or people by rail within New South Wales, including passenger (urban, regional and tourism) and freight (bulk, coal and commodity) rail transport. It excludes energy consumed in ancillary rail services and in the operation of train stations. Scope 2 emissions associated with the consumption of grid electricity are addressed in the electricity generation sector.

Activity data

Data used in the projection of NSW railway emissions are listed in Table 22.

Table 22 **Data referenced for projection of railway emissions**

Data reference	Description	Source
NSW population	NSW population projections based on common planning assumptions to 2060–61	DPE 2022g
Australian Energy Statistics	Annual energy consumption in NSW for rail transport	Cth DCCEEW 2022b
Bureau of Infrastructure and Transport Research	Kilometres travelled	BITRE 2021

Data reference	Description	Source
Economics rail statistics		
ARTC and TfNSW – rail network data	Gross tonne kilometres (GTK)	NSW rail network data provided by the Australian Rail Track Corporation (ARTC) and TfNSW (not public)
NGERS facility-level reports	kL of fuel combusted in NSW, emissions by type	Confidential data provided by the Clean Energy Regulator
NSW Greenhouse Gas Inventory	NSW rail emissions (2011–2021)	Cth DCCEEW 2023d
TfNSW	Utilisation of passenger trains to allow for energy usage adjustment for passenger numbers	TfNSW 2022e
TfNSW	Train patronage – monthly figures	TfNSW 2022e

Projections approach

Emissions for passenger trains were projected based on NSW population projections to 2050, accounting for trends in passenger movements over the period 2016–2022. Historical passenger movements are taken from Opal data and used to derive average passenger movements per population (passenger:population ratio). The impact of the COVID-19 pandemic on passenger movements is observed in a significant drop in passenger:population ratios for 2020, 2021 and 2022. While 2022 is higher than 2021, it has still not recovered to the pre-COVID year 2019.

The assumed COVID-19 recovery year is pushed out to 2025–26, with future passenger numbers from this point projected based on the pre-COVID-19 passenger:population ratio. Passenger numbers for 2023 are assumed to be the same as 2022, with 2024 increase to an average of 2022 and pre-COVID. The diesel consumption for passenger trains is then projected based on a diesel intensity factor (kL per passenger movement), which is derived from historical diesel consumption data (2016–2020). The diesel intensity is also calculated for the pre-COVID-19 and COVID-19 periods.

Emissions for freight trains are estimated based on projected diesel consumption, derived based on commodity projections (GTK) and the historical fuel efficiency (L per GKT) for each commodity (derived from historical data 2016–2018). Fuel efficiency improvements for freight are also considered within the business as usual scenario, with a 10% improvement in fuel efficiency assumed as a progressive linear annual improvement from 2020 to 2030. The abatement included for fuel efficiency is based on existing industry targets and commitments to decarbonise, for example:

- Aurizon has set a target of 10% emission intensity reduction by 2030, outlined in their 2020 *Climate strategy and action plan* (Aurizon 2020)

- Pacific National has committed to 50 new C44 Evolution locomotives in their fleet between 2021 and 2026, resulting in 9% less emissions than existing NR class locomotives and the installation of trip optimiser software on all existing NR class locomotives, with reported fuel savings of 6% (Pacific National 2021).

Domestic waterborne navigation

This subsector includes scope 1 emissions associated with all civilian (non-military) marine transport of passengers and freight, including coastal shipping (freight and cruise ships), interstate and urban ferry services, and other vessels and small pleasure craft movements in New South Wales. Fuel use in military vessels and international shipping is excluded. Similarly, energy usage at ports, marinas and other ancillary marine functions is included within other sector inventories.

Activity data

Data used in the projection of NSW navigation emissions are listed in Table 23.

Table 23 Data referenced for projection of navigation emissions

Data reference	Description	Source
NSW population	NSW population projections based on common planning assumptions to 2060–61	DPE 2022g
Australian Energy Statistics	Annual fuel consumption in NSW for domestic (coastal) water transport	Cth DCCEEW 2022b
Bureau of Infrastructure and Transport Research Economics statistics	Port based maritime activity	BITRE 2022b
	Australian aggregate freight forecasts	BITRE 2019
National Greenhouse and Energy Reporting Scheme facility-level reports	kL of fuel combusted in NSW, emissions by type for water freight and passenger transport and water support services	Confidential data provided by the Clean Energy Regulator
NSW Greenhouse Gas Inventory	NSW domestic navigation emissions (2011–2021)	Cth DCCEEW 2023d
Opal	Public transport on ferries trip data	TfNSW 2022d

Projections approach

Fuel use for domestic navigation is disaggregated into categories (coastal shipping, water passenger/ferries transport and other vessels/small pleasure craft). NGERS data includes fuel (and emissions) for water freight transport, water passenger transport and water transport support services. The AES provide total fuel consumption for water transport by fuel type (fuel oil, diesel and auto-gasoline). The AES include fuel used for military use, and this is therefore removed based on an assumption that 31.1% of diesel use in this subsector is military (DISER 2022b). When military fuel is excluded, the annual contribution of each fuel type to total fuel consumption in this subsector is ~10–20% fuel oil, ~35–40% diesel and 40–50% auto-gasoline (based on AES data from 2016–2020).

STGGI emissions data is disaggregated by fuel type using these splits, resulting in a derived (back calculated) fuel consumption that is very similar to the AES. Fuel consumption is then assigned to the categories as follows:

- all fuel oil is assigned to coastal shipping (and taken from the STGGI normalised fuel consumption)

- diesel and gasoline for coastal shipping is taken from NGERS reported fuel consumption for water freight transport and support services
- diesel and gasoline for passenger/ferries is taken from NGERS reported fuel consumption for water passenger transport
- diesel and gasoline for other vessels and pleasure craft is the difference between total STGGI derived fuel and NGERS fuel assigned to the other categories.

Disaggregation of emissions into the categories above allows emissions projections to be derived separately, using different growth assumptions where appropriate. Emissions for ferries and other vessels and pleasure craft are projected based on NSW population projections to 2050, with a linear increase in emissions assumed with population. Emissions for coastal shipping are projected based on Bureau of Infrastructure and Transport Research Economics projections for coastal shipping to 2041 (BITRE 2022b), with a linear trend continued from 2042 to 2050.

A summary of the estimated emissions by category is presented in Figure 22.

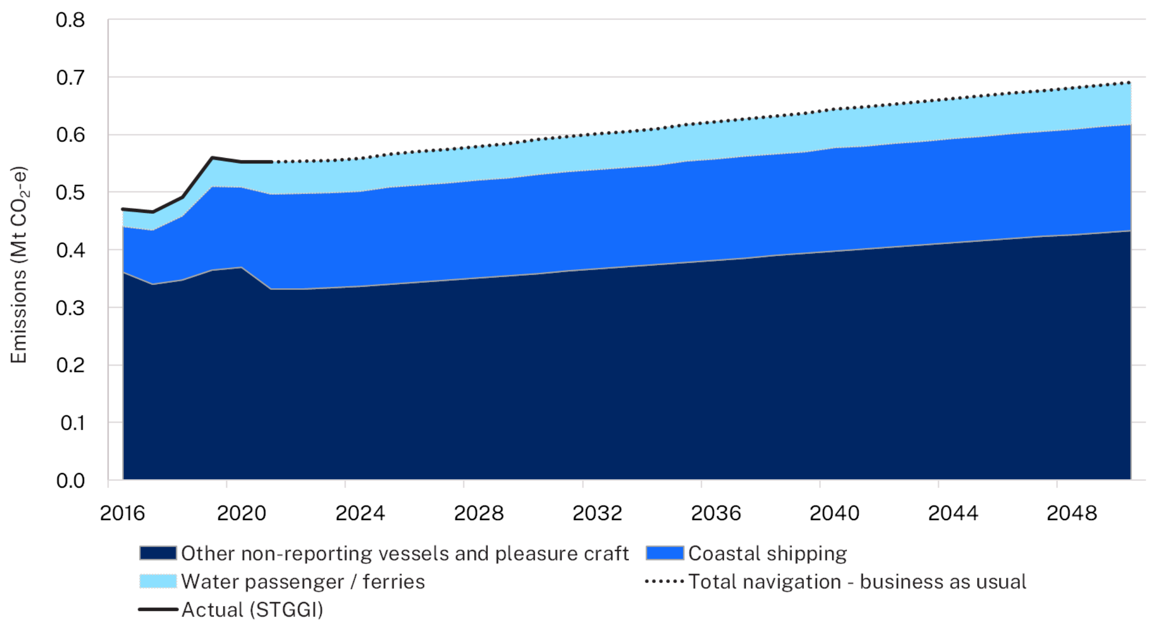

Figure 22 **Emission estimates for subcategories in the domestic waterborne navigation subsector**

Other transport sources (pipeline transport, off-road)

There are 2 subcategories included in this subsector: pipeline transport and off-road recreational vehicles.

Pipeline transport

This sector includes combustion-related emissions from use of pipelines to transport gases, liquids, slurry and other commodities. The sector is dominated by natural gas pipelines, with the combustion of natural gas making up approximately 90% of the reportable scope 1 emissions from the other transport sources subsector. Two main gas pipeline operators report 100% of the natural gas consumption for the subsector.

It is noted that fugitive emissions from natural gas pipelines are addressed separately under natural gas transmission and storage (refer to the ‘Fugitive emissions from fuels’ sector).

Activity data

Data used in the projection of NSW pipeline transport emissions are listed in

Table 24.

Table 24 Data referenced for projection of pipeline transport emissions

Data reference	Description	Source
NSW population	NSW population projections based on common planning assumptions to 2060–61	DPE 2022g
Australian Energy Statistics	Annual fuel consumption in NSW for ‘Other transport, services and storage’	Cth DCCEEW 2022b
National Greenhouse and Energy Reporting Scheme facility-level reports	NSW emissions for pipelines and other transport	Confidential data provided by the Clean Energy Regulator
NSW Greenhouse Gas Inventory	NSW domestic navigation emissions (2011–2021)	Cth DCCEEW 2022d

Projections approach

Business as usual emissions from pipeline transportation are projected based on NSW population projections to 2050, with a linear increase in emissions assumed with population.

Off-road recreational vehicles

This sector includes combustion-related emissions from the use of off-road mobile sources, such as unregistered trail bikes, recreation vehicles and competition vehicles.

Off-road vehicles that are classified in ‘1.A.4 Other Sectors’ are dealt with elsewhere and are excluded from this subsector, for example:

- commercial/institutional off-road vehicles
- residential off-road vehicles such as lawn mowers
- agricultural forestry and fishing off-road vehicles
- military transport.

Activity data

Data used in the projection of NSW off-road recreational vehicles are listed in Table 25.

Table 25 Data referenced for projection of off-road recreation vehicle emissions

Data reference	Description	Source
NSW population	NSW population projections based on common planning assumptions to 2060–61	DPE 2022g
Australian Energy Statistics	Auto-gasoline consumption in NSW for 'other transport services and storage'	Cth DCCEEW 2022b
National Greenhouse and Energy Reporting Scheme facility-level reports	kL of fuel combusted in NSW, emissions by type	Confidential data provided by the Clean Energy Regulator
NSW Greenhouse Gas Inventory	NSW emissions for 'other transportation' (2011–2021)	Cth DCCEEW 2023d

Projections approach

Business as usual emissions from off-road recreation vehicles are projected based on NSW population projections to 2050, with a linear increase in emissions assumed with population.

Current policy assumptions

Current policy projections for the transport sector consider the projected abatement due to Net Zero Plan programs and related NSW Government policies (Table 5).

The NSW Electric Vehicle Strategy, as originally designed, aims to ensure more than 50% of new car sales are EVs by 2030. Actions under the strategy include rebates for EV buyers, fleet incentives for business and councils, and investment in EV charging infrastructure. The current focus for the EV strategy is to build a world-class EV charging network, with an updated cost–benefit analysis (CBA) currently underway.

A base case and a policy case for BEVs and plugin hybrid EVs were modelled by Veitch Lister Consulting for the Electric Vehicle Strategy. These uptake rates were used for current policy projections in the previous projections update. The previously modelled EV uptake rates were compared against sales to date (to June 2023). For some vehicle categories (small passenger cars, large light commercial vehicles) the actual sales of EVs are significantly less than the BAU and policy case modelled for the EV strategy. For other categories, the actual sales are higher than the policy case modelled for the EV strategy. BEV sales for medium-size passenger cars, for example, are far in excess of the modelled scenario for the EV strategy, largely driven by the success and availability of the Tesla Model 3. Overall, when all vehicle categories are combined, the actual sales to date are similar to the modelled scenario for the EV strategy. However, to account for the different uptake rates across the different vehicle categories, the fleet and emissions model for light vehicles has been updated to account for the latest sales trends. Uptake rates are adjusted based on actual sales for each category and brought back to the EV strategy curve based on an assumed smooth transition.

The updated fleet and emissions modelling for light vehicles has projected a small increase in abatement for light vehicles compared with the previous update, with 0.3 Mt more in 2030 and 0.6 Mt more 2035.

Abatement for the *Zero Emission Bus Transition Strategy* (TfNSW 2022a) is included for the heavy vehicle subsector, providing for the transition of NSW's 8,000 strong bus fleet to zero emission buses by 2035. As of mid-2023, approximately 200 battery electric buses are on NSW roads, accounting for 2.5% of the fleet. No change to the abatement for the Zero Emission Bus Transition Strategy is included in this update. The *NSW Hydrogen Strategy* (DPIE 2021f) sets out policies to drive decarbonisation in hard to abate sectors, including transport. Relevant 2030 stretch targets in the plan include the production of 110,000 t of green hydrogen per year; achieving a hydrogen price under AU$2.80 per kg; provision of 100 refuelling stations; achieving 10,000 hydrogen vehicles in the NSW stock; and including 20% of the NSW Government heavy vehicle fleet being hydrogen fuelled. Abatement modelled by KPMG for the hydrogen strategy is adopted but adjusted for hydrogen truck uptake already assumed in the BAU.

The *Future Transport Strategy* (TfNSW 2022b) outlines TfNSW's commitment to achieving net zero emissions from their operations and fleet by 2035, with actions including the procurement of 100% renewable energy; electrifying TfNSW's buses, ferries, corporate vehicles and non-passenger vehicle fleets; progressively identifying opportunities for strategic rail electrification; and supporting optimal use of green hydrogen. Addressing freight emissions is noted to be a priority in the strategy (TfNSW 2022b). Consistent with the Future Transport Strategy, current policy projections include emissions reductions for railways due to the regional rail project, which aims to upgrade the regional fleet to operate in bi-mode configuration (using overhead power when operating on the electrified section of the network and diesel–electric motors when operating outside the electrified network) (TfNSW 2022b). Also included in the 2023 update are abatement estimates for concessions on mass limits for heavy-duty vehicles, based on planned action from recommendations in the TfNSW *Net Zero Freight Policy* (TfNSW 2023).

Future action under stages 2 and 3 of the Net Zero Plan

Emissions reductions were also forecast for future actions under stages 2 and 3 of the Net Zero Plan under committed NSW Climate Change Fund funding. Based on the relative contribution of residual emissions in the transport sector from 2031 to 2050 and remaining opportunities for abatement, the projections assume that approximately 28% of the funding over 2030–2050 would be invested in driving further reductions in transport emissions, with a focus on aviation and residual road transport emissions.

Considerations for projection updates

Future projection updates will consider:

- updated EV uptake modelling accounting for revisions to the NSW Electric Vehicle Strategy and the Commonwealth's Fuel Efficiency Standard

- continued analysis of the pace of transition within the aviation industry, including industry commitments and technological advances
- updated evidence of the ongoing impacts, if any, of COVID-19 on-road transport and aviation
- abatement within the navigation sector, including fuel efficiency and emissions standard improvements for outboard engines, electrification of commercial and recreational vessels and renewable energy shore power for White Bay and Glebe Island
- impacts of policies and programs as they are rolled out, including actions under the Future Transport Strategy and Net Zero Freight Policy.

Fugitive emissions from fuels

Fugitive emissions from fuels refers to greenhouse gases (GHGs) released in connection with, or as a consequence of, the extraction, processing, storage or delivery of fossil fuels. This excludes combustion of fuels for the production of useable heat or electricity.

Summary of the emissions trends

Business as usual

Inventoried emissions (1990–2021) and business as usual (BAU) emissions projections (2022–2050) for the NSW fugitive emissions sector by subsector are shown in Figure 23. Emissions are expected to grow over this decade, reaching a maximum of 15.3 Mt CO_2-e in 2028, due mainly to increased coal mining activity and natural gas developments. Without abatement, fugitive emissions from fuels are projected to reach 14.5 Mt CO_2-e in 2030.

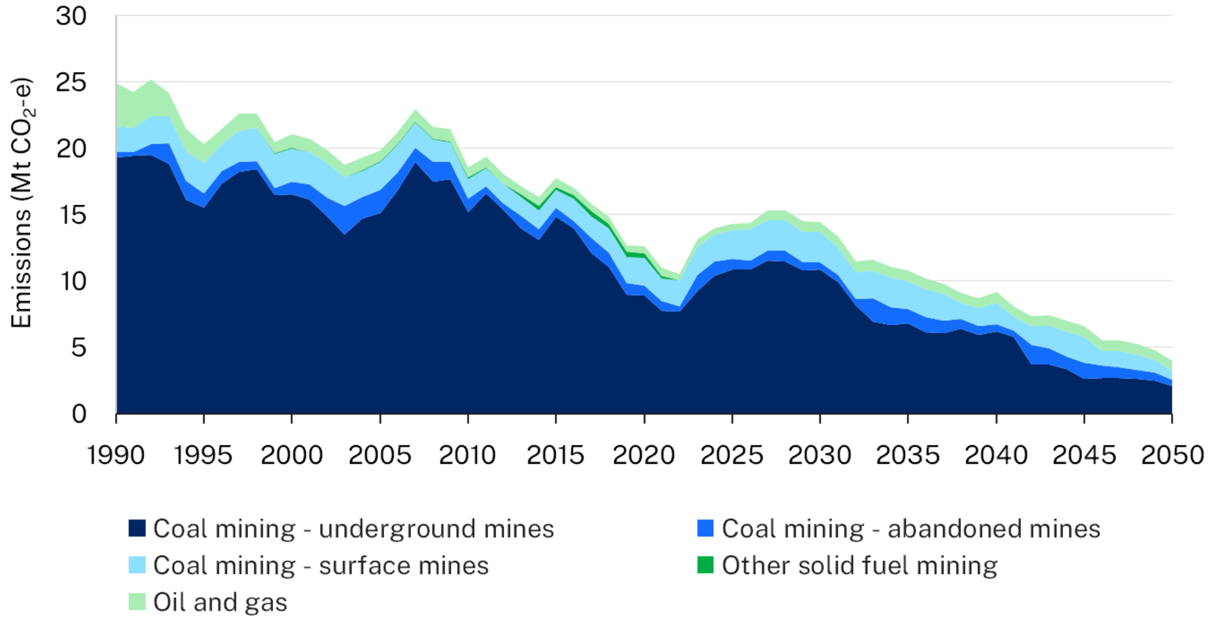

Figure 23 **Fugitive emissions by subsector showing inventory estimates (1990–2021) and business as usual emissions projections (2022–2050)**

Current policy

Abatement in this sector is projected to come from either programmatic funding, such as Net Zero Industry and Innovation Program (NZIIP) or leveraged by the Safeguard Mechanism reforms and EPA's climate change policy and action plan (CCPAP). Future action under stage 2 and 3 funding is also assumed to abate the emissions in this sector after 2030.

For this sector, no difference is currently identified between the abatement as originally designed scenario and the 'abatement as currently tracking' scenario, therefore a single current policy projection is presented. This is because reduced programmatic abatement, for example under NZIIP, is assumed to happen anyway under the declining baselines required under the Safeguard Mechanism and leveraged under EPA's CCPAP. The integrated abatement that is projected to be achieved is shown in Figure 24.

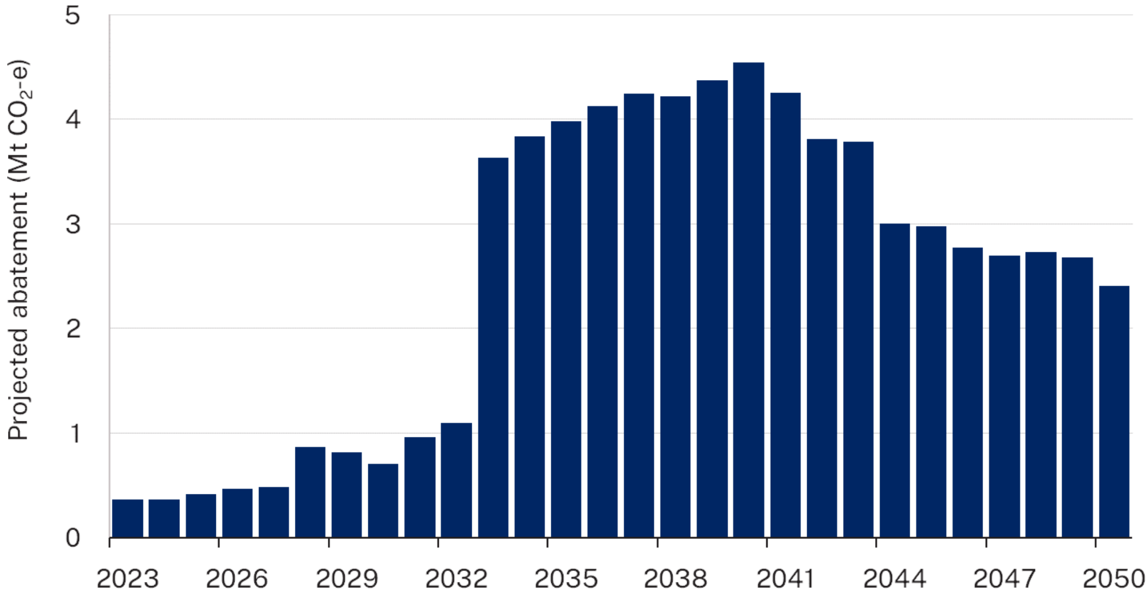

Figure 24 **Abatement of fugitive emissions from underground coal mining projected to be achieved by Net Zero Plan programs and related policies (2022–2050)**

The resultant current policy projections for this sector compared to BAU projections are shown in Figure 25. Emissions in the sector initially grow, due mainly to increased coal mining, after which they start to decrease as mining activity slows and programmatic abatement kicks in from 2033.

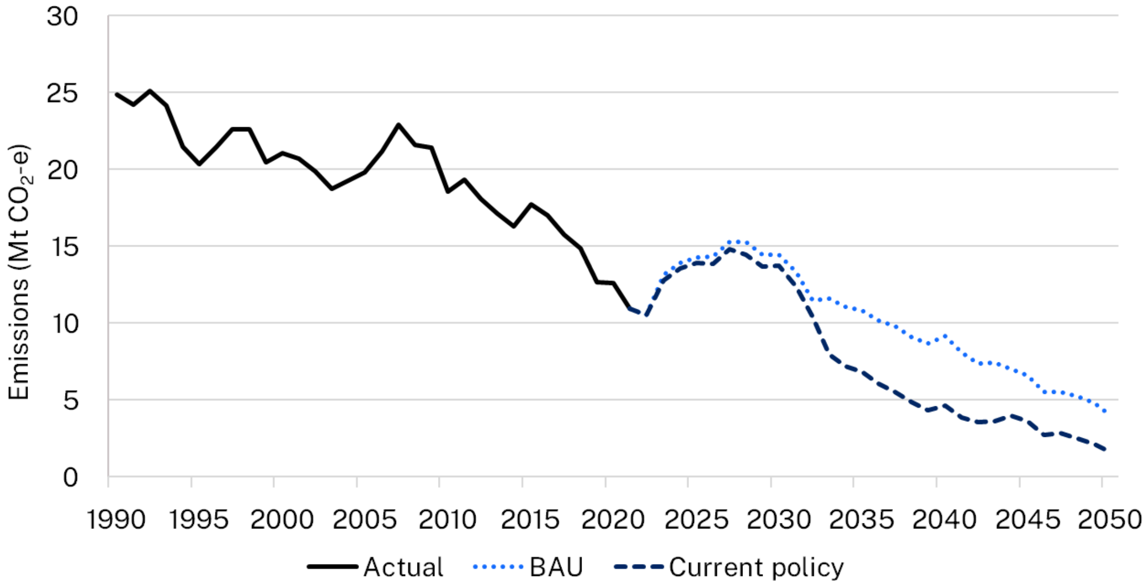

Figure 25 **NSW fugitive emissions (including coal and oil and gas) as inventoried (1990–2021), with business as usual (BAU) and current policy emissions projection (2022–2050)**

NSW fugitive emissions by subsector, with current policy abatement, are shown in Figure 26.

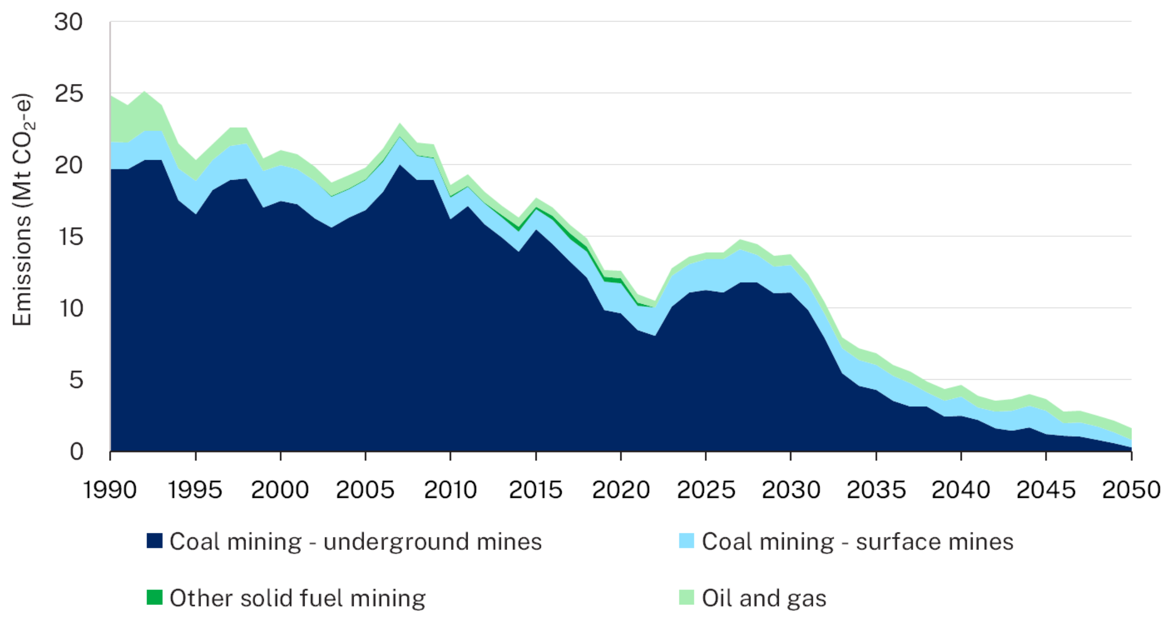

Figure 26 **Fugitive emissions by subsector showing inventory estimates (1990–2021) and current policy emissions projections (2022–2050)**

Summary of changes in emissions since last year's projection update

Coal and gas fugitive emissions are projected to be lower than the previous update (Figure 27). This is due to more refined emission intensities being used in the projections for coal mine extension projects with published site-specific measurements and scaling back of production forecasts for several mines in consultation with Department of Regional NSW (Mining, Exploration and Geoscience).

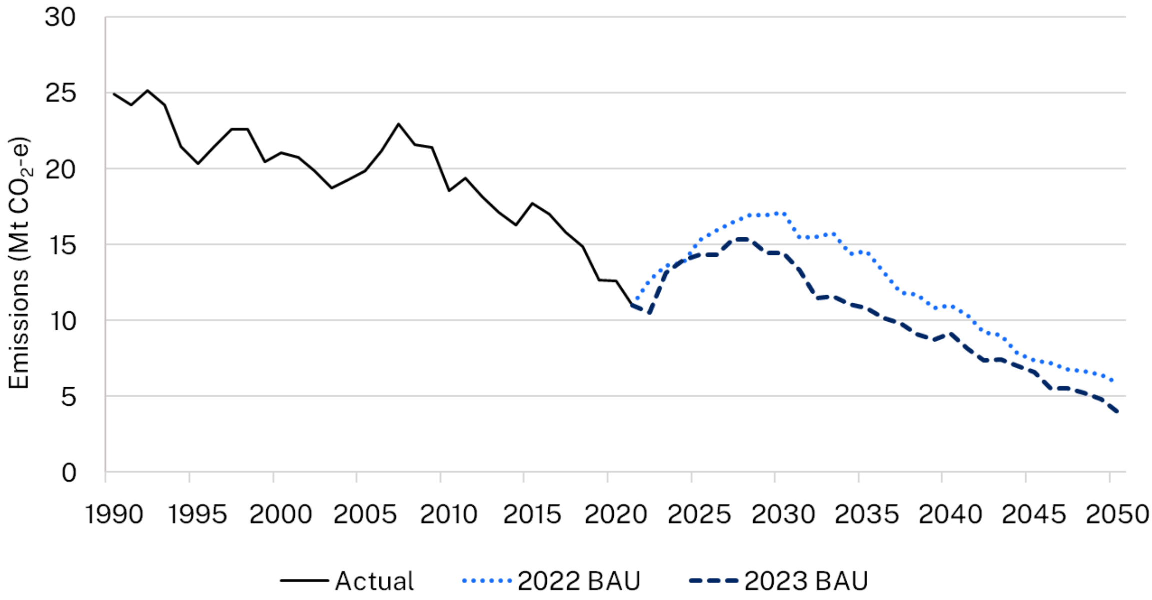

Figure 27 **Comparison of 2022 and updated 2023 business as usual (BAU) fugitive emissions projections**

The key changes in current policy projections for 2023 compared to 2022 were focussed on the replacement of diesel usage in mine vehicles with battery electric vehicles at open-cut coal mines, and the deployment of ventilation air methane (VAM) abatement technology at some gassy underground mines. Given the slow pace of trialling options for diesel replacement on mine sites, the turnover progress for mine site vehicle fleets was modelled to happen at a slower pace in the 2023 projections (i.e. starting at 5% in 2033 and reaching 100% turnover of the fleet by 2043) compared to the 2022 projections where turnover was modelled to be 40% by 2033 and 100% by 2036.

As discussed earlier, the deployment of VAM abatement technology at some gassy underground mines was pushed back to 2033 in the 2023 projections compared to 2028 in the 2022 projections. This is assumed to happen under NZIIP incentives or Safeguard Mechanism requirements.

Methodology and assumptions

BAU methodology and assumptions

Fugitive emissions are projected separately for coal mining, and oil and gas fugitives.

Data on recent fugitive emissions are sourced primarily from National Greenhouse and Energy Reporting Scheme (NGERS) facility emissions. Coal fugitive emissions projections for each mine are modelled using run-of-mine (ROM) coal production forecasts provided by the NSW Resources group in the Department of Primary Industries and Regional Development (previously the Minerals, Exploration and Geoscience group). Forecasted production and fugitive emissions figures reported by companies in, for example, environmental statements that accompany mine extension proposals, have also been used where such information was considered to be more up to date.

Gas fugitive emissions projections are based on the Australian Energy Market Operator's (AEMO) *2021 Gas statement of opportunities* (GSOO) forecasts of gas supply, particularly the central case (scenario 1) (AEMO 2021).

The GSOO 2022 (AEMO 2022b) and GSOO 2023 (AEMO 2023) did not include a central case forecast. A comparison of the 2021 and 2022 low gas price scenario gas production forecasts showed that the 2022 forecasts were on average 3% lower. As it was unclear how this change would affect the fugitive emissions from gas projects, the production forecasts were held at 2021 levels.

A more detailed description of the modelling for coal mining and oil and gas fugitives is given below.

Coal mining fugitives

Fugitive emissions from underground coal mines involve the release of methane (CH_4) and carbon dioxide (CO_2) during:

- coal extraction where coal seams, overburden and underburden strata are fractured
- post-mining activities where residual gases within the coal are released during the handling, transportation and stockpiling of coal
- the flaring of coal mine waste gas
- the venting or other fugitive release of gas from the underground mine before coal is extracted from the mine.

Fugitive emissions from open-cut mines in New South Wales generally result from the extraction process but can involve the other sources of emissions described for underground mines.

Fugitive emissions may also occur from decommissioned underground coal mines. This may include leakage to the atmosphere through fractured gas-bearing strata, open vents and seals over daily to decadal timescales. However, emissions will be reduced by flooding of the mine, which prevents desorption of gases from the remaining gas-bearing strata in the decommissioned mine.

Active open-cut and underground coal mining

Coal mining fugitive emissions data are sourced by mine based on data reported under NGERS. Projections for these emissions are calculated as a function of future ROM coal production using mine-specific emission intensity factors based on the latest reported emissions and on ROM coal production forecasts.

Historical ROM coal production data is externally sourced from Coal Services Pty Ltd (Coal Services 2023). ROM coal production data is also obtained from the NGERS matters to be identified data as a cross-check. Fugitive emission intensity factors (based on the latest financial year reported) are calculated per mine as tonnes of carbon dioxide equivalent (CO_2-e) per tonne of ROM coal.

Coal production is projected to 2050 using the Department of Regional NSW (Mining, Exploration and Geoscience [MEG]) 'most likely' ROM coal production forecasts (June 2023). Sensitivity testing is conducted based on assumptions regarding potential minimum and maximum coal production scenarios. The 'most likely' coal production scenario includes forecasts based on current mine approval dates as well as intended extensions beyond current approval dates, as indicated by operators in consultation with MEG. The minimum coal production scenario is based on current mine approval dates and possible closures before approval dates, as indicated by operators in consultation with MEG. The maximum coal production scenario is based on the 'most likely' scenario but also includes strategic release areas. Future emissions are calculated for each mine by multiplying the latest fugitive emission factor by the projected ROM coal tonnages; this assumes continuous extraction of coal with no changes in the gassiness (i.e. changes in gas content and composition) of the seams being worked. This is assumed as data on changes in gas properties as mining progresses are not available and are kept confidential by coal mine operators.

Modelling approach

The fugitive emission factor $EF_{j,T}$ is derived according to:

$$EF_{j,T} = \frac{E_{j,T}}{Q_{j,T}}$$

where:

$EF_{j,T}$ = the emission factor in tonnes of CO_2-e per tonne of ROM coal produced by mine *j* and base year *T*

$E_{j,T}$ = the total fugitive emissions for mine *j* and base year *T* sourced from NGERS in tonnes of CO_2-e; this includes coal extraction related emissions, venting, flaring and post-mining emissions

$Q_{j,T}$ = the quantity of ROM coal produced for mine *j* and base year *T* in tonnes, sourced from Coal Services.

For the projection of total fugitive emissions for facility *j* and year *t* (where t > T):

$$E_{j,t} = Q_{j,t} \times EF_{j,T}$$

where:

$E_{j,t}$ = the projected fugitive emissions for mine *j* and year *t* in tonnes of CO_2-e

$Q_{j,t}$ = the projected quantity of ROM coal produced for mine *j* and year *t*

$EF_{j,T}$ = the emission factor in tonnes of CO_2-e per tonne of ROM coal produced by mine *j* and base year *T*.

The $Q_{j,t}$ is obtained from the NSW Department of Regional NSW (Mining, Exploration and Geoscience) ROM coal production forecasts (Department of Regional NSW 2023).

Exceptions

For underground coal mining, NGER methods 1–4 are allowable depending on the type of fugitive emission. For open-cut mining, methods 1–3 are also allowable, however, method 1 is based on a state average emission intensity factor (also based on ROM coal production) that can lead to inaccurate GHG estimates.

Mt Pleasant was the only open-cut coal mine to use method 1 to report fugitive emissions to NGERS. Fugitive emissions projections for Mt Pleasant were thus based on a site-specific emissions factor reported in their optimisation plan.

In general, fugitive emissions data for open-cut mines are checked for the NGERS method used. If NGER method 1 is used, advice is sought from the Australian Department of Industry, Science, Energy and Resources (DISER) on the best approach and alternative emission factors are used.

Decommissioned coal mines

Decommissioned mine emissions are projected using a model utilising NGERS method 1 for decommissioned mines. The model uses historical emissions, coal production and date of closure. The input data for currently decommissioned mines was obtained from the matters to be identified dataset. For mines forecast to be decommissioned in the next 1–2 years, the variables had to be estimated. The variables include:

- date of mine closure – estimated as the last day of the financial year when the mine is to be decommissioned
- total coal mined – estimated using the total ROM coal produced for the mine provided by NSW Department of Regional NSW (Mining, Exploration and Geoscience)
- mine gassiness – depends on the region in which the coal is mined – coal mined in western New South Wales tends to be less gassy whereas coal mined in the Southern Highlands or the Hunter Valley tends to be gassy
- flooding constant (F_{dm}) – emissions are proportional to the time that a mine is flooded. This variable is back-solved using the variables above and the last reported NGERS emissions for the facility.

These variables are then used to calculate emissions (t CO_2-e) using NGERS method 1. For facilities with reported emissions and no historical coal production data available, a ratio of emissions by projected year over the base year (2021–22) for facilities with data is applied.

Modelling approach

Under NGERS method 1 the emissions for decommissioned underground mines are calculated by:

$$E_{dm} = \left(E_{t,dm} \times EF_{dm} \times (1 - F_{dm})\right)$$

where:

E_{dm} = the fugitive emissions of CH_4 from the mine during the year measured in t CO_2-e

$E_{t,dm}$ = the fugitive emissions from the mine for the last full year the mine was in operation measured in t CO_2-e

EF_{dm} = the emission factor for the mine

F_{dm} = the proportion of the mine flooded at the end of the year and must not be >1.

EF_{dm} is calculated by the following:

$$EF_{dm} = \int_{T-1}^{T} (1 + A \times t)^{b} - C \, dt$$

where:

T = the number of years since the mine was decommissioned

A, *b* and *C* are constants that depend on whether the mine is gassy or non-gassy.

F_{dm} is calculated by the following:

$$F_{dm} = \frac{M_{WI}}{M_{VV}} \times T$$

where:

M_{WI} = the rate of water flow into the mine in cubic metres per year – this can either be measured or have fixed values depending on whether the mine is located in the southern coalfields or in the Newcastle, Hunter, Western or Gunnedah regions

M_{VV} = the mine void volume in cubic metres

T = the number of years since the mine was decommissioned.

For currently decommissioned mines, E_{dm} is reported in NGERS, and EF_{dm} is calculated using data reported in the matters to be identified dataset, namely the gassiness of the mine, F_{dm} and the mine closure date.

For mines soon to be decommissioned, the input data includes an estimate of mine closure date used for T, the appropriate average water inflow rates for M_{WI} and the total tonnes of ROM coal mined, divided by 1.425 to give the void size (M_{VV}). These parameters are then used to compute F_{dm} .

Key changes compared to the 2022 projections

The following changes were made for the 2023 projections:

- Dartbrook is projected to operate between 2022 and 2023 and 2026 and 2027 and return to decommissioning thereafter.
- Myuna is projected to operate until 2031–32 rather than 2029–30.
- Fugitive emissions and ROM production forecasts for the Hunter Valley Operations Continuation Project were updated based on their recent extension amendment.
- The ROM production forecast for Boggabri was updated based on their Modification 8 environmental impact statement (EIS), which scales back production to 2034–35.
- Mt Thorley Warkworth operations are projected to continue to 2036–37 (and not beyond 2050).
- Dendrobium is projected to operate to 2029–30.
- Based on consultation with company representatives, Narrabri will continue their south extension operations to 2043–44 and the Gorman North area was removed from the most likely projection given uncertainties associated with this extension.
- The ROM production forecast for Moolarben Open Cut Modification OC3 is included in the projection for Moolarben Open Cut.
- Production at Stratford was scaled back to 2023–24 from 2039–40.

Gorman North remains the only strategic release area, but is only included in the 'maximum' coal production scenario.

Emissions from decommissioning at 34 underground mines were included in the current projections.

Oil and gas fugitives

This section focuses on the fugitive emissions produced by the gas industry as there is essentially no oil refining industry in New South Wales since the closure of the Kurnell oil refinery in 2014.

The fugitive emissions of CH_4 and CO_2 associated with gas supply relate to:

- natural gas exploration, which includes emissions from drilling, flaring during exploration and emissions from well completions and workovers
- natural gas production, which includes leakages from onshore wells and well-pad operations, onshore gas gathering and boosting equipment and stations, water production, including compressors, dehydrators, pipelines and treatment plants
- natural gas processing plant leakages
- natural gas transmission pipeline and storage leakages
- natural gas distribution pipeline leakages including emissions
- fugitive emissions of both CH_4 and CO_2 from venting and flaring from gas production and processing.

For gas transmission pipelines, fugitive emissions are fixed as these emissions only depend on the length of the pipeline, for example, the Moomba Sydney Pipeline and the Eastern Gas Pipeline.

For gas distribution networks, the forecast fugitive emissions depend on the annual terajoules (TJ) of utility gas sales. For the largest distribution network in New South Wales, the Jemena Gas Network, information on future forecasts in utility gas sales are being requested from Jemena. For the purpose of the 2023 projections, the average of the 7 years of NGERS fugitive emissions data (2015–16 to 2020–21) was taken as constant over the projection period.

For most other smaller distribution networks, future trends in utility gas sales are similarly not known, with emissions fixed at the average of the 7 years of NGERS fugitive emissions data over the projection period.

The fugitive emissions forecasts included 3 key developments: 1) the Port Kembla Gas Terminal (PKGT); 2) the Narrabri Gas Project (NGP); and 3) the Queensland–Hunter Gas Pipeline. The PKGT and NGP were assumed to commence operations in 2023 and 2026, respectively. The commencement of the NGP was delayed by one year as per consultation with Santos. Fugitive emissions data for the NGP and PKGT were obtained from the EIS available in the public domain. The EIS provided emissions data for maximum production values.

The main gas production forecasts for the NGP and PKGT were modelled using the AEMO GSOO central case (scenario 1) (AEMO 2021) after reviewing the available data in GSOO 2022 and GSOO 2023 as discussed above. The fugitive emissions were scaled according to the fraction of production in a given year compared to maximum production.

In the case of the NGP, the BAU scenario assumes imported grid electricity based on a decarbonising grid with the NSW Electricity Infrastructure Roadmap being implemented.

The Queensland–Hunter Gas Pipeline was assumed to be delivering gas in 2025, and it is assumed it will be delivering gas from the NGP (and Queensland) to Sydney. According to the EIS (DPIE 2019), there will be no gas compression in New South Wales and therefore the emissions are only due to pipeline fugitives (which depend only on the length of the pipeline and are therefore constant over time).

The AEMO GSOO 2021 projections extend to 2040, with emissions forecast to 2050 held constant at 2040 values.

Current policy assumptions

Opportunities to abate fugitive emissions have been identified for NSW coal mines in recent studies commissioned by NSW Government agencies. In a 2021 assessment of abatement opportunities at NSW's gassiest underground coal mines (Palaris 2021), gas drainage and VAM abatement opportunities were identified at 8 underground coal mines. The study found 80 Mt CO_2-e of abatement in mines under BAU, and 110 Mt CO_2-e of potential additional abatement over the life of these mines. It recommended a transition to longer term emissions forecasting, mine planning and abatement, maximising CH_4 gas capture and utilisation, and/or CH_4 destruction through flaring. A key recommendation was for mines to pre-drain CH_4 gas from coal seams as early as possible.

A more recent study (Palaris 2022) identified opportunities for abating fugitive emissions at underground and open-cut mines. After considering cost, technology readiness, scalability, emissions reduction potential, viability and lead times for implementation, the study recommended the consideration of:

- pre-drainage and gas flaring (2-year horizon) and gas utilisation (5-year horizon) at open-cut mines
- optimisation of pre- and post-drainage (2-year horizon), improved ventilation strategies (5-year horizon) and VAM abatement technologies (10-year horizon) at underground mines.

Abatement of fugitive emissions is within the current scope of NZIIP, and particularly the high emitting industry focus area, with priorities including:

- Priority 1 – deploy opportunities to reduce industrial emissions ($200 million), for example, pre-mining and/or goaf gas drainage with power generation or flaring
- Priority 2 – accelerate strategic abatement opportunities ($105 million), for example, VAM abatement
- Priority 3 – develop low carbon infrastructure and industrial precincts ($55 million).

The program is currently being reviewed and future updates to the projections will incorporate revised abatement projections for the program, including interaction with the Safeguard Mechanism.

The Coal Innovation NSW (CINSW) funded South32 VAM abatement demonstration facility project will support progress towards VAM abatement in the sector. This project includes site trials and demonstration of a full-scale next-generation thermal unit (known as VAMMIT) with a safe ducting system at South32 Illawarra Metallurgical Coal. Project outcomes include full-scale VAMMIT demonstrated with improved safety and commercial viability.

The 2023 current policy projections assume the anticipated NSW EPA CCPAP and the reform of the Safeguard Mechanism by the Australian Government will support the adoption of available technologies leveraging current investments under NZIIP and CINSW.

Based on a mine-by-mine analysis of the extent of mine emissions, the remaining mine life and findings from technical feasibility studies, emissions reductions of 3–4 Mt CO_2-e per year were estimated to be achievable from this sector between 2032 and 2050. VAM abatement at gassy underground mines contributes significantly to this estimate and if this measure is applied after 2032 the estimated abatement will primarily materialise in the 2030s and 2040s.

Technological advances could result in opportunities for abatement to occur earlier and may support further abatement opportunities such as options for achieving greater abatement at open-cut mines. A limited number of initiatives are currently funded under NZIIP incentives. The current policy projections thus assume initiation of VAM abatement will only be plausible at some gassy underground mines from 2032–33, pushing back abatement forecasts. If this abatement does not materialise under NZIIP, it is assumed to happen anyway under the declining baselines required under the Safeguard Mechanism and leveraged under EPA's CCPAP.

It is further assumed that future actions under stages 2 and 3 of the Net Zero Plan under committed NSW Climate Change Fund funding are able to deliver deeper abatement.

Considerations for projection updates

Future projection updates will:

- consider the latest NGERS data, EIS information for new projects and updated coal and gas production and consumption forecasts (considering forecasts from major gas suppliers if available)
- revisit assumptions regarding the likely uptake of incentives to abate coal mining fugitives under NZIIP, and the potential for further abatement as a result of revised policies and market trends
- revisit the estimated fugitive emissions reductions to be achieved from the full-scale VAM abatement project at South32's Illawarra coal mine, co-funded by CINSW (Department of Regional NSW 2023)

- consider the impact of new corporate commitments announced and potential changes to the Australian Government's Safeguard Mechanism on the emission intensity projections for coal and gas fugitives.

Industrial processes and product use

The industrial processes and product use (IPPU) sector includes emissions that are released as a result of the chemical reactions that take place in the manufacture of, for example, cement, aluminium and steel, and the use of products such as synthetic gases (i.e. hydrofluorocarbons [HFCs] used as refrigerants).

Summary of the emissions trends

Business as usual

Business as usual (BAU) emissions projections account for production or commodity forecasts, sectoral efficiency and productivity improvements (in place of assuming the emission intensity of future production will remain constant) and firm corporate commitments. Inventoried emissions (1990–2021) and BAU emissions projections (2022–2050) for the NSW IPPU sector by subsector are shown in Figure 28.

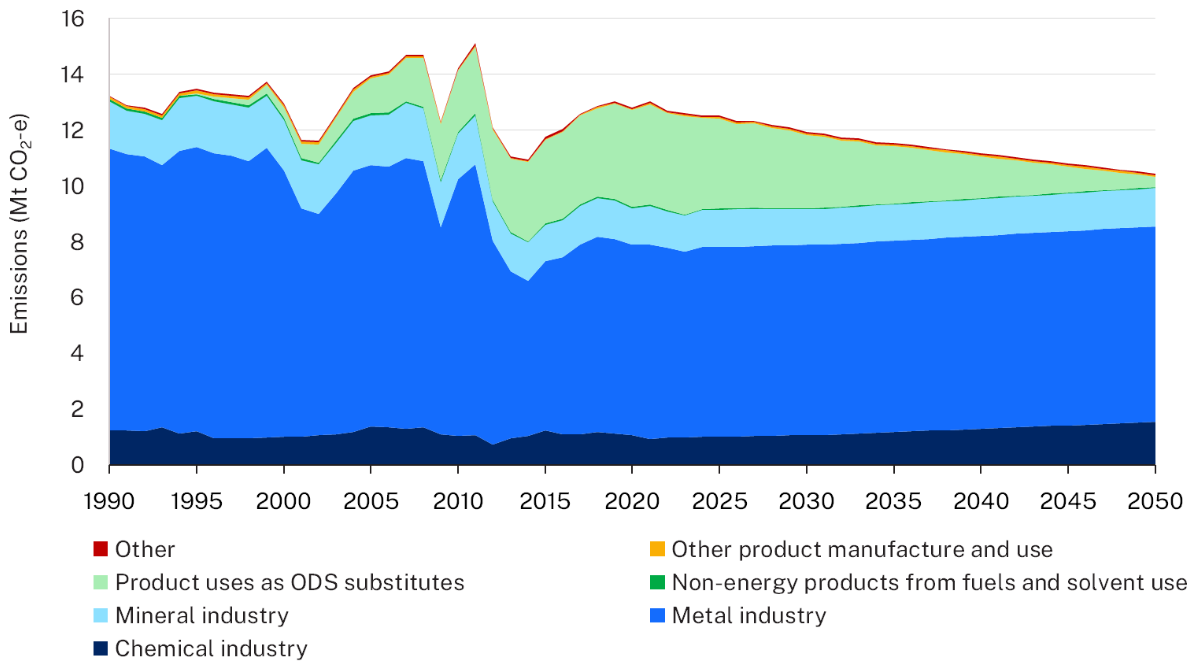

Figure 28 **Industrial processes and product use emissions by subsector showing inventory estimates (1990–2021) and BAU emissions projections (2022–2050)**

This sector currently produces about 10% of NSW emissions at 12.6 Mt CO_2-e. Future emissions for the IPPU sector are projected to drop slowly in the medium term, decreasing by about 8% to 2030 and 11% to 2035. Emissions decrease to 11.6, 11.2 and 10 Mt CO_2-e in 2030, 2035 and 2050, respectively. This decrease is primarily driven by the phase-down of the import of HFCs.

Assuming no significant shift in the emission intensity of industrial processes, sector emissions are projected to grow in line with commodity forecasts in the longer term.

Metal production (iron, steel, ferro-alloys, aluminium and others) account for more than half of the sector's emissions, with smaller contributions from the minerals and chemicals industries.

Abatement identified under the BAU scenario includes:

- reduction of perfluorocarbons (PFCs) in aluminium production
- clinker replacement, process improvements and CO_2 sequestration (e.g. through mineral carbonation processes) in cement production
- a demonstration-scale mineral carbonation plant proposed for the Orica Kooragang Island facility in ammonia production.

No BAU abatement was identified for iron and steel IPPU emissions. Significant process changes through the use of the hydrogen direct reduced iron (DRI) process (a pathway opportunity) for example, is needed to achieve significant emissions reductions. Similarly, pathway opportunity exists in green ammonia, through switching from natural gas to hydrogen. The large iron and steel and ammonia production facilities are pursuing research and development-scale investigations of the various 'green' production technologies, but no firm commitment to full implementation has been made at this stage. These pathways are considered and discussed further in the current policy projection.

Another major emission source is halocarbon replacements for ozone-depleting substances, such as refrigerant gases in imported equipment, which has accounted for about a quarter of sector emissions in recent inventory years. The Australian Government has a program to phase-down the import of goods containing halocarbons with high global warming potential. The NSW Government has no complementary measures for reducing HFCs at this time.

Current policy

Abatement in this sector is based on programmatic funding under Net Zero Industry and Innovation Program (NZIIP) and the NSW Hydrogen Strategy, plus opportunities for onsite abatement leveraged by the Safeguard Mechanism reforms and EPA's climate change policy and action plan (CCPAP). Future action under stage 2 and 3 funding is also applied for this sector. To account for uncertainty in abatement that may be able to be achieved in this sector, 2 abatement scenarios are presented.

Under the cautious 'abatement as currently tracking' scenario, abatement that was originally targeted under NZIIP has been removed, as the program has indicated that it will not achieve the original targets as designed. The program is currently being reviewed and future updates to the projections will incorporate revised abatement projections for the program, including interaction with the Safeguard Mechanism.

For New South Wales to remain on track to achieve its targets, emission reductions equivalent to NZIIP's original targets would be needed, under either NZIIP, Safeguard

Mechanism and/or supported by the EPA's CCPAP. This is reflected in the abatement as originally designed scenario.

The integrated abatement that is projected to be achieved under the 2 scenarios is shown in Figure 29. The large step changes in abatement seen in 2040 and 2045 reflect assumptions made for implementation of green steel at BlueScope Port Kembla and green ammonia at Orica Kooragang Island (discussed further under current policy assumptions).

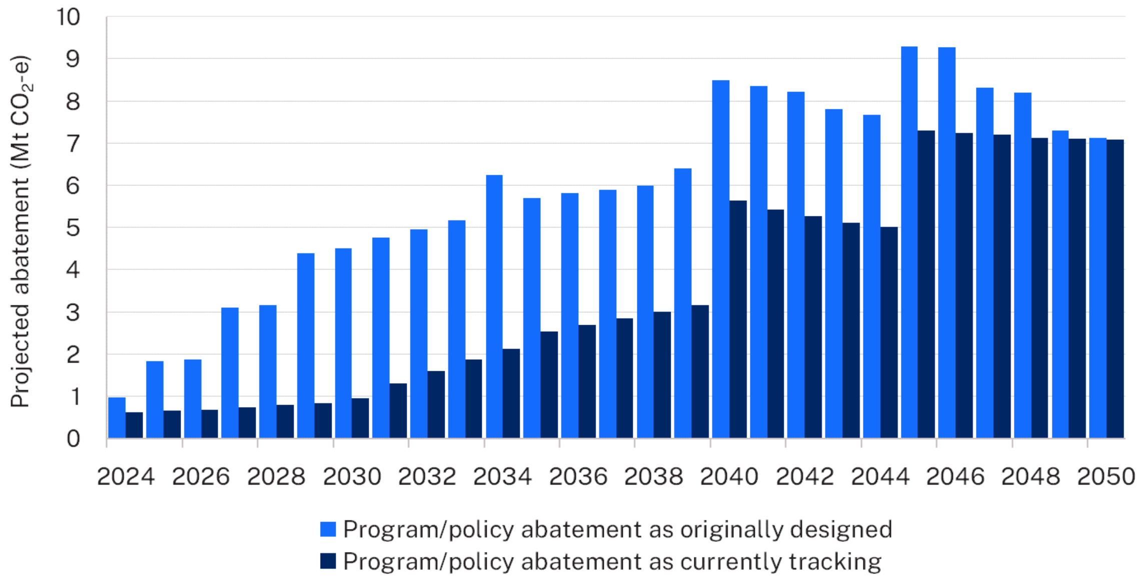

Figure 29 **Abatement of industrial processes and product use emissions projected to be achieved by Net Zero Plan and related policies (2023–2050)**

The resultant range in current policy projections for this sector is shown in Figure 30. Further details on the assumptions for current policy are presented in subsequent sections. The difference between the abatement as originally designed and the 'abatement as currently tracking' projection is effectively the reduced abatement assumptions under the NZIIP program. The large step changes in abatement seen in 2040 and 2045 reflect assumptions made for implementation of green steel at BlueScope Port Kembla and green ammonia at Orica Kooragang Island, which is onsite abatement that is assumed to occur to meet Safeguard Mechanism reform obligations (discussed further under current policy assumptions).

The peer review found that the abatement estimates to be reasonable, however, noted that they rely on several significant assumptions around breakthrough technologies, availability of large amounts of low-cost hydrogen, and business decisions, and were therefore assigned a low level of confidence. Only the abatement as originally designed scenario was peer reviewed, therefore this finding is addressed, at least partly, by the more cautious 'abatement as currently tracking' scenario, with a lower level of abatement assumed. It is noted, nevertheless, that the scenario still relies on transformative changes from 2040, for example, in iron and steel.

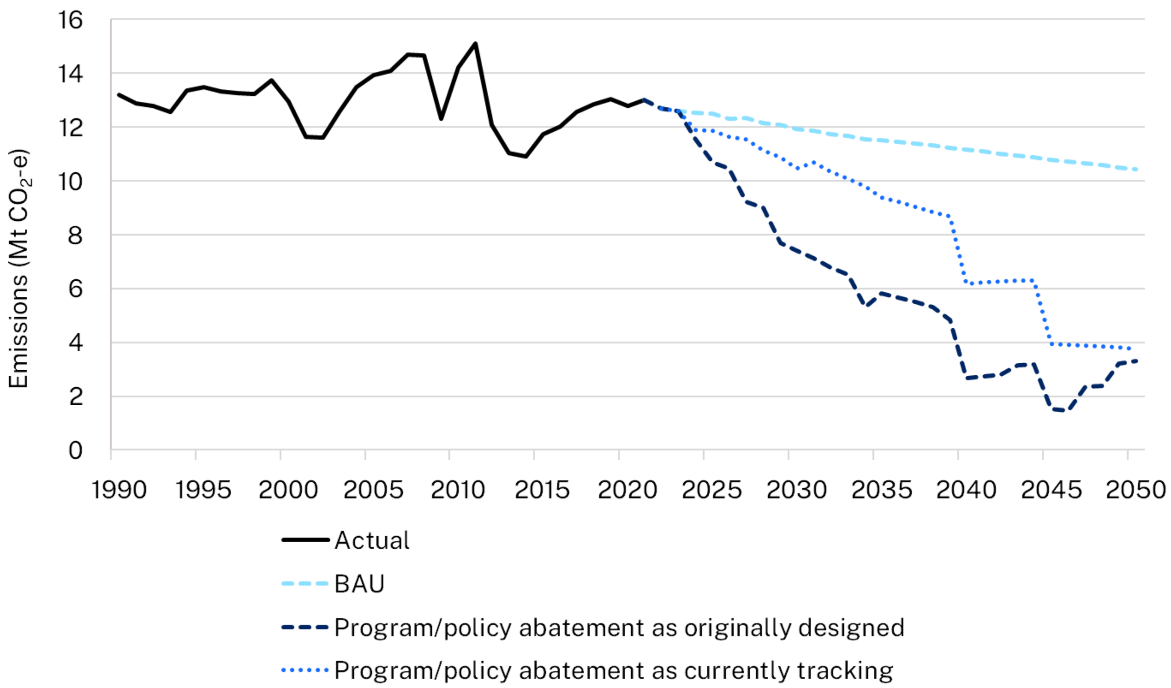

Figure 30 **NSW industrial processes and product use sector emissions as inventoried (1990–2021), with business as usual (BAU) and current policy projections ranges (2022–2050)**

Summary of changes in emissions since last year's projection update

From 2022 to 2037, updated BAU emissions for IPPU are projected to be higher than published in 2022 (Figure 31), mainly due to increased activity in the sector (higher production) post-COVID-19. Towards 2050, the updated BAU projections are lower, mainly due to lower commodity growth forecasts for iron and steel.

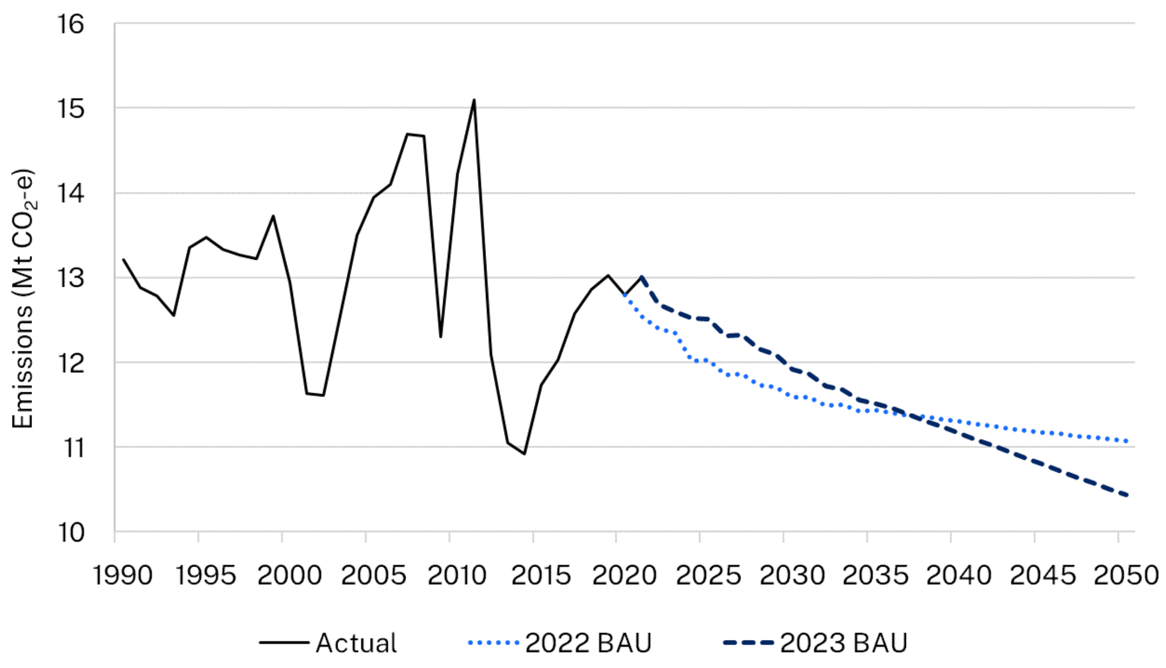

Figure 31 **Comparison of 2022 and updated 2023 business as usual (BAU) emissions projections for the industrial processes and product use sector**

Methodology and assumptions

Business as usual methodology and assumptions

Bottom-up model

Facility-specific projections were applied for industries in New South Wales for which facility-level production data were available. The emissions are calculated according to the formula:

$$E_t = E_{t-1}\ \Delta production$$

where:

E_t = emissions in year t (tonnes CO_2-e)

E_{t-1} = emissions in the previous year

$\Delta production$ = percentage change in production between year t and year t–1.

Top-down model

A top-down model is applied when the bottom-up model is not possible due to the availability of data. This uses either revenue projections or population projections, for example:

- revenue projections from IBISWorld (IBISWorld 2022), based on IBISWorld revenue growth rates
- population projections (DPE 2022g), where the emissions are calculated according to the formula:

$$E_t = E_{t-1}\ \Delta population$$

where:

$\Delta population$ = percentage change in population between year t and year t–1.

The following changes were made for these projections:

- 2023 Office of the Chief Economist *Resources and Energy Quarterly* (OCE REQ) forecasts for steel and aluminium production were updated, with lower compound annual growth rates for 2029–2050.
- In the iron and steel subsection, MolyCop Waratah (formerly Commonwealth Steel Waratah) is excluded from 2025 due to its announced closure in February 2024.
- Orica's corporate abatement from carbon capture, utilisation and storage mobile demonstration plant was updated.

Chemicals industry

The chemical industry subsector includes ammonia and nitric acid production, and consumption of acetylene, anaesthetics and aerosols. Historical IPPU emissions were collated from National Greenhouse and Energy Reporting Scheme (NGERS) facility data for the sector.

Ammonia production

For ammonia production, 2 growth scenarios were considered for the Orica Kooragang Island facility (the largest ammonia production facility in New South Wales), as follows:

- a steady growth scenario (capped at about 0.330 Mt p.a.)
- a domestic growth scenario.

The domestic growth scenario was selected as the main BAU scenario because the planned ammonia plant expansion and upgrade plan will likely increase the ammonia and ammonia nitrate production (Orica 2022a). Published information from Orica was used in the domestic growth scenario assuming that ammonia production will grow linearly from ~0.330 Mt p.a. in 2022 to 0.385 Mt p.a. in 2030. Production is capped at 0.385 Mt p.a. from 2030 (Orica 2022a). Current greenhouse gas (GHG) emission intensities for 2022 are assumed to remain constant until 2050. Orica's commitments for onsite abatement are outlined in Table 26.

Table 26 Public abatement commitments for ammonia production

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
Carbon capture, utilisation and storage (demonstration plant)	2024–2050	Total reduction 3,000 t CO_2-e p.a. (Orica 2022b)	$14.6 million Australian Government funding for MCi to establish a mineral carbonation mobile demonstration plant at the Orica site (MCi 2021)

Orica's *Climate action report* (Orica 2023) discusses switching from natural gas to hydrogen produced from renewable electrolysis as a promising opportunity to eliminate emissions over the long term. However, Orica notes that it will depend on the cost-effective supply of large quantities of renewable electricity, the extent and speed of cost reductions for electrolysis and growth to commercial scale.

The production of green ammonia via switching to hydrogen is considered a pathway opportunity rather than business as usual or current policy abatement. Table 27 summarises green ammonia opportunities identified for the Orica Kooragang Island facility.

Table 27 Green ammonia opportunities for Orica Kooragang Island

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
Green ammonia (switch from natural gas to renewable hydrogen)	2027–2050	Total emissions reduction of 0.015-0.3 Mt CO_2-e p.a.	Discussed by proponent (Orica 2023) and Orica's presentation in 2023

Nitric acid production

For nitric acid production, 2 growth scenarios were also considered for the Orica Kooragang Island facility (the largest nitric acid production facility in New South Wales), as follows:

- a steady growth scenario based on Cth DCCEEW's emissions projections 2020 for chemicals (DISER 2020a)
- a domestic growth scenario (capped at 0.605 Mt p.a.).

The domestic growth scenario was selected as the main BAU scenario because of the planned nitric acid plant expansion (Orica 2022a).

From 2023 to 2030, Cth DCCEEW's growth forecasts from the 2020 emissions projection are used (Table 28). For 2031–2050, published information from Orica is used. This assumes that the additional nitric acid plant will be completed in 2030, and production of nitric acid will grow linearly from 2031 to reach 0.605 Mt p.a. in 2050. The maximum capacity is 0.605 Mt p.a. (Orica 2022a).

Table 28 Australian Government forecasts for chemical industry, percentage change in production (2023–2031)

2023	2024	2025	2026	2027	2028	2029	2030	2031
2.4%	1.0%	0.4%	0.5%	0.9%	0.9%	0.9%	0.4%	0.5%

As per the stationary energy emissions projections for chemicals, for 2023–2031, Australia's 2020 chemical industry emissions projections (DISER 2020a) are used instead of the 2021 and 2022 projections. This is because the 2021 and 2022 projections had included the Emissions Reduction Fund EnviNOx project at Orica Kooragang Island, with production from other smaller facilities also factored in.

No additional abatement is identified for nitric acid production in the BAU.

Note that:

- continued operation of selective nitrous oxide (N_2O) catalyst abatement at Orica is already accounted for through lower emission intensities based on recent NGERS data
- the proposed Kooragang Island Decarbonisation Project involving EnviNOx implementation to deliver a 48% reduction in site emissions is co-funded by the NSW Government and is therefore accounted for within current policy projections.

Acetylene, anaesthesia and aerosols

For acetylene, anaesthesia and aerosols, a population projection approach is used for the BAU projections. There is no specific facility emissions data under NGERS, therefore NSW data from the State and Territory Greenhouse Gas Inventory (STGGI) (Cth DCCEEW 2023f) for carbide processing was used as the basis for the calculation. The data is scaled by the annual percentage change in NSW population (DPE 2022g) as per Cth DCCEEW projection methods.

Metals industry

This sector covers the aluminium industry through production and consumption of carbon anodes and fluorocarbon gases. It also covers iron and steel (coke consumption) and lead-alloys.

Iron and steel production

Several BAU emission scenarios have been considered, based on the ongoing steel production from 2 facilities (BlueScope Port Kembla and InfraBuild Steel Mill Sydney). MolyCop Waratah is excluded from 2025 due to its announced closure in Feb 2024. Scenarios considered included the Transport for NSW (TfNSW) commodity demand forecasts (TfNSW 2022g) and the Bloomberg New Energy Futures' *New energy outlook 2021* (BNEF NEO 2021) growth scenario (BNEF 2021a).

The OCE projection scenario (for 2023–2028) and domestic growth scenario (using the OCE compound annual growth rate [CAGR] for 2029–2050) were selected as the BAU main scenario. This projection better reflects the future production capacity and provides a central estimate between the upper (TfNSW 2022g) and lower limit (BNEF 2021a) scenarios.

The main scenario for steel production is identical to that assumed for stationary energy related iron and steel emissions. The current GHG emission intensity for 2022 is assumed as a constant until 2050.

For 2023–2028, data from the OCE Sep 2023 *Resources and Energy Quarterly* (REQ) forecast (DISR 2023a) and March 2023 REQ forecast (DISR 2023b) (covering 2026–2028) are used (Table 29).

Table 29 **Office of the Chief Economist forecasts for iron and steel percentage change in production (2023–2028)**

2023	2024	2025	2026	2027	2028
−2.59%	2.66%	0.00%	0.00%	0.05%	0.31%

From 2029–2050, a domestic growth scenario is assumed with new production expansion continuing. The steel production growth rate is assumed to be equal to the OCE CAGR of 0.1%, as stated in the OCE REQ March 2023 forecast (DISER 2023b).

A review of GHG emissions abatement actions for Port Kembla Steelworks identified actions already implemented, such as increased use of scrap steel in production (BlueScope 2021). The emissions reductions of these actions are already accounted for within the BAU projections. This is reflected in the NGERS data, where the emission intensity calculated for 2020–21 is about 2% lower than in 2018–19.

Reference is made to the green steel technology identified for the Port Kembla Steelworks (i.e. a pathway opportunity) (Table 30), however, this measure is not included in the BAU projections, rather it is considered a future pathway opportunity to address Safeguard Mechanism obligations.

Table 30 **Green steel opportunities for Port Kembla Steelworks**

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
Green steel – hydrogen DRI, (DRI–Melter-BOF or DRI-EAF)	2040–2050	Total reduction starts at 2.3 Mt CO_2-e in 2040 up to 4.7 Mt CO_2-e p.a. (ERM 2023)	BlueScope in its 2021–22 Sustainability Report (BlueScope 2022b) notes that it: • is installing and commissioning a 10 MW hydrogen electrolyser to explore and test green hydrogen in its blast furnace operations at Port Kembla Steelworks (possible blending with natural gas) • is exploring the establishment of a hydrogen hub in the Illawarra region • has commenced a concept study on producing low emissions iron through the use of direct reduced iron (DRI) from Pilbara iron ores. The intention is to develop this DRI using green hydrogen, produced from renewable electricity

Aluminium production

The major emission source in this subsector is from aluminium production. The emissions projections are based on the percentage change in output from the Tomago Aluminium facility. Scenarios considered included a steady production scenario and the BNEF NEO 2021 growth scenario (BNEF 2021a).

A domestic growth scenario was chosen based on OCE forecasts (2023–2028) and a CAGR from 2029–2050. For 2023–2028, a combination of data from the OCE REQ September 2023 (DISR 2023a) and OCE REQ March 2023 (DISR 2023b) were used (Table 31).

Table 31 Office of the Chief Economist forecasts for aluminium percentage change in production (2023–2028)

2023	2024	2025	2026	2027	2028
−0.07%	2.24%	0.08%	−0.72%	0.04%	−0.03%

For 2029–2050, the domestic growth scenario (OCE CAGR) assumes that new production expansion will continue. The aluminium production growth rate is assumed to be equal to the OCE CAGR of 0.4%, as stated in the OCE REQ March 2023 forecast (DISER 2023b). Tomago Aluminium's current production capacity is near 0.6 Mt p.a. Despite there not being any further development plans, the future production capacity was assumed to grow based on the domestic growth scenario. The current GHG emission intensity for 2022 is assumed as a constant until 2050.

Tomago's commitments for onsite abatement were outlined in Table 32.

Table 32 Abatement commitments for aluminium

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
Reduce perfluorocarbon (PFC) emission	2023–2050	Total reduction increases 0.6% p.a. and stays at 6% from 2030. PFC emissions account for 12% of the total scope 1 emissions; assumes that 50% of PFCs will be captured	Safeguard Mechanism website (CER 2020). Tomago Aluminium has several PFC emissions reduction trials underway and has committed to installing an upgraded version of its pot control system in 2020 that has the potential to reduce PFC emissions in operations

Lead production

The scale of emissions from lead recycling is relatively small in the metal industry. One facility converts used lead acid batteries into metallic lead for reuse. The lifetime of a lead acid battery is assumed to be 5 years. To forecast the production of recycled lead, a simple model was used based on the percentage change in number of vehicles.

To forecast the change in recycling rates for used lead acid batteries, the linear regression of the change in the number of registered motor vehicles in Australia is used. This data is obtained from the ABS *Motor vehicle census, Australia* (ABS 2021). The emissions for a domestic growth scenario projection are calculated according to the formula:

$$\mathrm{E_t} = \mathrm{E_{t-1}}\ \Delta number\ of\ vehicles\ (\mathrm{t}-5)$$

where:

$\mathrm{E_t}$ = emissions in year t (tonnes CO_2-e)

$\mathrm{E_{t-1}}$ = emissions in the previous year

$\Delta number\ of\ vehicles\ (\mathrm{t}-5)$ = the percentage change in the number of vehicles between year t–6 and year t–5. This time delay refers to the 5-year lifetime of a lead acid battery.

Mineral products

This sector includes cement clinker use, lime production, glass production (use of carbonates), magnesium production, soda ash use, iron and steel (use of carbonates), ceramic production and other unspecified use of limestone and dolomite. The sector is split into the 8 subsectors listed above and NGERS facility emissions data aggregated for each subsector.

Cement clinker production

The BNEF NEO 2021 growth forecast for cement clinker production in Australia (BNEF 2021a) was adopted as the proxy for modelling the BAU growth in cement and lime production.

Boral’s Berrima facility production data is used as the basis for the BAU main scenario projection for clinker. The clinker production capacity is about 1.4 Mt p.a. (Boral 2022a). Given the continuous growth of the Australian population and construction activities, it is assumed that the future cement clinker production gradually increases to 1.76 Mt p.a. in 2050, according to BNEF NEO 2021 scenario (BNEF 2021a).

The current GHG emission intensity for cement clinker production at the Boral Berrima facility in 2022 is assumed constant until 2050.

Boral’s commitments for onsite abatement were discussed in Boral’s 2022 sustainability report (Boral 2022b) as shown in Table 33.

Table 33 Abatement commitments for cement clinker production

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
Clinker substitution and other process improvements	2023–2050	Reductions range from 3% in 2023 up to 14% by 2050	Corporate commitment
Carbon capture, utilisation and storage (pilot plant for mineral carbonation)	2028–2050	Total reduction starts at 50,000 t CO_2-e in 2028 up to 100,000 t CO_2-e p.a. in 2030 by applying low emissions intensity lime and cement technology	$30 million from the Australian Government's Carbon Capture, Use and Storage Development Fund, collaboration with Calix (Calix 2022)

Other subsectors

The forecast for iron and steel (use of carbonates) is correlated to the production projection of iron and steel (see iron and steel subsector under 'Metals industry' above). Using the BAU main scenario projection, the percentage change in iron and steel production is assumed to be the same as the percentage change in use of carbonates. The current GHG emission intensity for 2022 is assumed as a constant until 2050.

The remaining 5 subsectors are forecast based on the revenue/production growth rates given in Table 34, based on IBISWorld forecasts (IBISWorld 2022) to 2026.

After 2026, a linear regression was applied to extend the projection to 2050. The exceptions to the above are magnesium production and unspecified limestone and dolomite use. For magnesium production, emissions are a fixed value over time as only one relatively small facility in New South Wales produces magnesium (based on data provided by Cth DCCEEW). Only 2 relatively small facilities in New South Wales contribute to emissions from unspecified limestone and dolomite use, so these are also held fixed over time.

Table 34 Revenue and production for mineral product subsectors (2023–2026)

Produce subsector	2023	2024	2025	2026
Glass production	1.5%	2.9%	2.5%	2.2%
Magnesium production	–	–	–	–
Unspecified limestone and dolomite use	–	–	–	–
Soda ash use	1.5%	2.9%	2.5%	2.2%
Ceramics	5.7%	1.5%	0.2%	2.5%

Product uses as a substitute for ozone-depleting substances

This sector comprises emissions of synthetic gases from the use of halocarbons in refrigeration and air conditioning, foam blowing, fire extinguishers, aerosols/metered dose inhalers and solvents. A complete description of the sector is given in the *National inventory report 2020* (DISER 2022b).

Historical emissions of halocarbon substances are estimated based on the STGGI data (Cth DCCEEW 2023f), with the NSW share of the total mass of HFCs in Australia attributed based on the percentage of the state's population.

Based on the *Cold hard facts* report (DAWE 2020, 2021) the Australian Government is phasing-down the importation of equipment with halocarbon refrigerants. HFC consumption is being phased down from 2018 towards a target to be achieved in 2036. The target, capped by the Australian Government, is 15% of the average of HFC imports and 75% of average hydrochlorofluorocarbon (HCFC) imports for 2011–2013.

As detailed data on HFC and HCFC containing stock (e.g. air conditioners and refrigerators) is not available for New South Wales, Cth DCCEEW's emissions projections from 2023–2035 were adopted, with an assumed linear trend in emissions for 2036–2050. According to Cth DCCEEW (2022b), the projections also account for the impact of proposed measures to inform refrigeration and air-conditioning equipment owners of the benefits of regular maintenance. These measures will reduce refrigerant leaks, improve the energy performance of refrigeration and air-conditioning equipment, and reduce emissions from HFCs.

Other – non-energy

Non-energy products from fuel and solvent use

Facility data for this subsector is not captured under NGERS, therefore, the tonnes of lubricant used is based on data provided by Cth DCCEEW (2023d). Emissions are calculated using the relevant energy content and emission factors. For projections to 2050, 2020 emissions are adjusted for annual percentage changes in NSW population (DPE 2022g).

Other product manufacture and use

The subsector covers sulfur hexafluoride leaks from electrical switchgear, emissions of nitrous oxide from aerosol products, and anaesthesia and polymer use. Facility data for this subsector is not captured under NGERS, therefore, recent historical emissions were obtained from Cth DCCEEW. Projections to 2050 used 2020 as the base year and future emissions were calculated by adjusting for annual percentage changes in the NSW population (DPE 2022g).

Current policy assumptions

Industrial process emissions within manufacturing are specifically addressed by NZIIP, including the high emitting industry, new low carbon industry foundations and clean technology focus areas. The Business Decarbonisation Support program supports emissions reductions within primarily medium to large energy users in industrial and commercial sectors, and the NSW Hydrogen Strategy will also support abatement within this sector.

For NZIIP, emission reductions in the abatement as originally designed scenario are based on the original targets outlined in the program's design. For the more cautious 'abatement as currently tracking' scenario, abatement under the program is not included. As a result, the 2030 abatement for all programs/policies is approximately 80% lower for the more cautious 'abatement as currently tracking' scenario. The program is currently being reviewed and future updates to the projections will incorporate revised abatement projections for the program, including interaction with the Safeguard Mechanism.

Current policy abatement for IPPU includes the EnviNOx N_2O abatement project at the Orica Kooragang Island facility, which is supported by the NZIIP program. Additional emissions reductions were also projected for the IPPU sector under stages 2 and 3 of the Net Zero Plan under committed Climate Change Fund funding based on top-down modelling.

The projections assume earlier implementation of green steel at BlueScope Port Kembla and green ammonia at Orica Kooragang Island supported by investment under the NSW Hydrogen Strategy, *Australia's National Hydrogen Strategy* (COAG Energy Council 2019) and associated federal funding, corporate commitments and plans and breakthrough technologies for local steelmaking. Abatement of up to 2.4–4.7 Mt CO_2-e for green steel after 2040 and about 0.3 Mt CO_2-e for green ammonia starting in 2035, is assumed in the projections. This is considered as potential onsite abatement, supported by programs (NZIIP) and/or leveraged by policy (Safeguard Mechanism reforms and EPA's CCPAP). No other abatement from market forces is considered for IPPU.

Considerations for projection updates

Future projections updates will continue to incorporate the latest available data, including NGERS data and the latest commodity forecasts. Potential market impacts of the European Union Carbon Border Adjustment Mechanism and the implications of growing corporate carbon reduction commitments will continue to be considered.

It is expected that the NSW EPA's CCPAP, the reform of the Safeguard Mechanism and NZIIP will all support the adoption of abatement technologies across industrial sectors. Further work is needed to understand how these related policies will interact, help drive onsite abatement and be counted for future projections updates.

Agriculture

Emissions from agriculture comprise emissions from livestock and crop production. They include emissions from enteric fermentation, manure management and agricultural soils. These emissions are predominantly nitrous oxide (N_2O) and methane (CH_4).

Summary of the emissions trends

Business as usual

Inventoried emissions (1990–2021) and business as usual (BAU) emissions projections (2022–2050) for the NSW agriculture sector are shown in Figure 32 by commodity. Emissions from agriculture vary from year to year due to the influence of climate, and particularly drought, on livestock numbers and crop production.

Cattle and sheep production accounted for approximately three-quarters of NSW agriculture emissions in 2021, mainly due to the CH_4 generated as these ruminant animals digest their food. Enteric fermentation is projected to remain the major source of agricultural emissions to 2030, with emissions increasing in the near term as the state recovers from the recent drought.

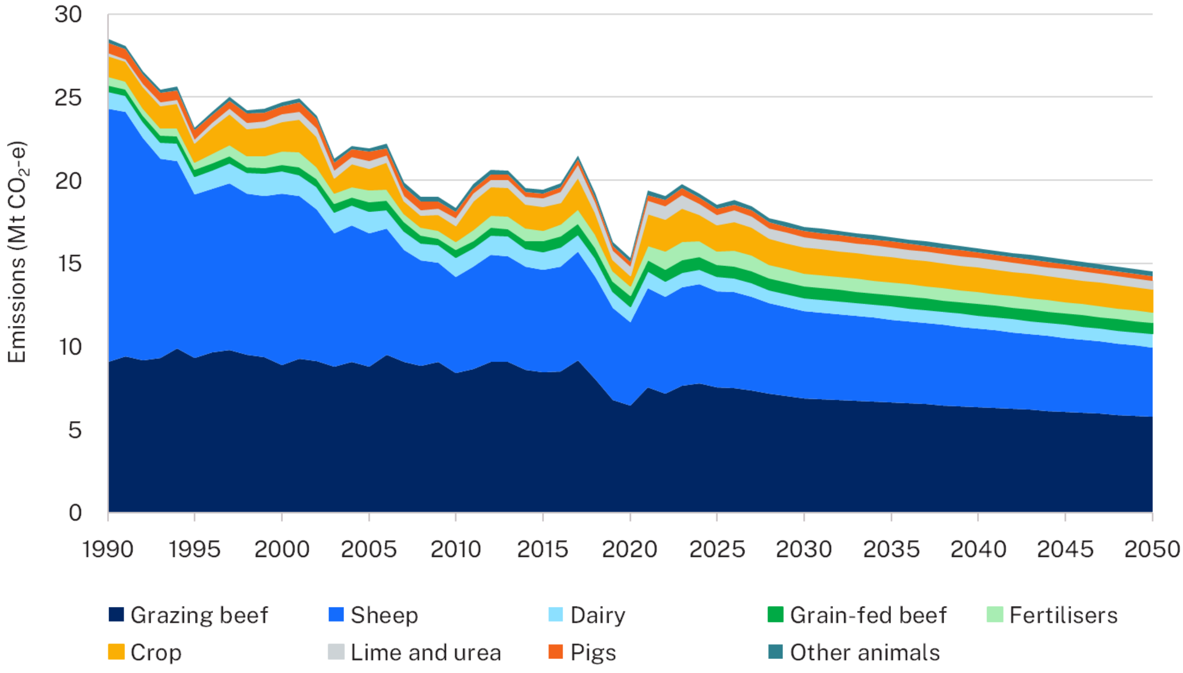

Figure 32 **Agriculture emissions by commodity showing inventory estimates (1990–2021) and business as usual emissions projections (2022–2050)**

Current policy

Abatement in this sector is projected to come from herd management and feed additives, supported by the Primary Industries Productivity and Abatement Program (PIPAP). Future action under stage 2 and 3 funding is also considered.

Updated modelling for PIPAP (i.e. focus area 2 – building critical mass and capacity) in 2023 resulted in less projected abatement being realised through the program, as a result of changes to funding, co-investment and carbon price assumptions (GHD 2023). The updated PIPAP modelling is based on already committed grants/projects (mostly sequestration in the land sector) and future priorities for the next funding rounds. The abatement of enteric fermentation will be prioritised for agriculture, assumed in the modelling to be achieved through dietary modification for dairy cattle and herd management of grazing cattle.

The independent peer review classified the assumptions for technical efficacy of enteric methane abatement as overly optimistic and not supported by evidence. Therefore, to account for uncertainty in abatement that may be able to be achieved in this sector, the 'abatement as currently tracking' uses a more cautious adoption rate and technical abatement potential for dietary modification. Further detail on the assumptions is presented in subsequent sections.

The projected abatement range in the agriculture sector is shown in Figure 33, accounting for the more cautious adoption rate and technical abatement potential under the abatement as currently tracking scenario. The resultant current policy projections for this sector compared to BAU projections is shown in Figure 34.

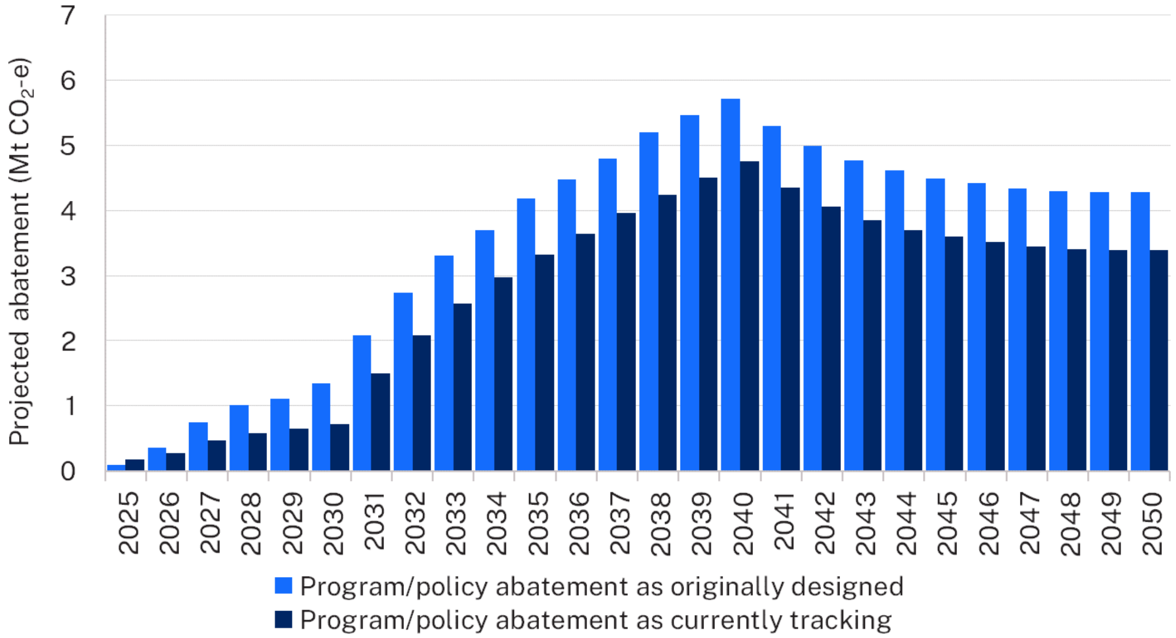

Figure 33 **Abatement of agriculture sector emissions projected to be achieved by Net Zero Plan programs, related policies and market impacts (2025–2050)**

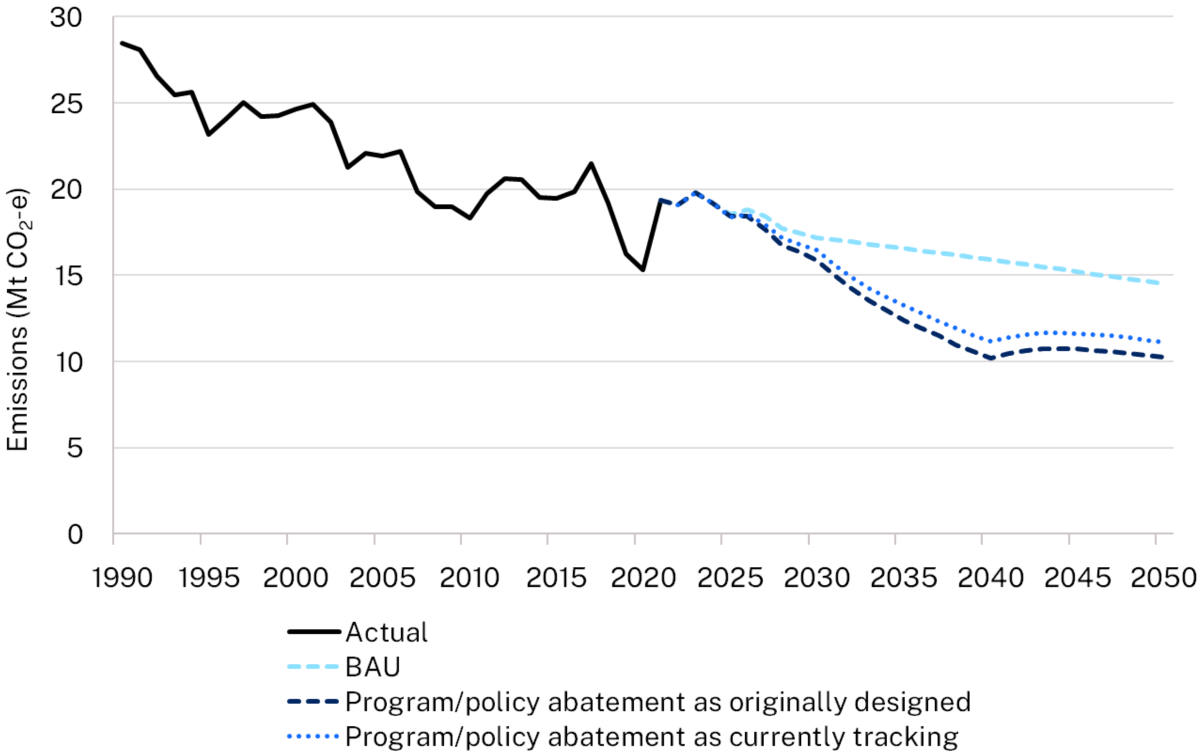

Figure 34 **NSW agriculture sector emissions as inventoried (1990–2021), with business as usual (BAU), current policy and cautious outlook scenario projections (2022–2050)**

Summary of changes in emissions since last year's projection update

The 2023 BAU emissions projections for the agriculture sector show an increase of up to 2.7 Mt CO_2-e compared to the figures published in 2022 for the period spanning from 2022 to 2041 (Figure 35). However, from 2042 to 2050, they are anticipated to be 0.1 to 1.0 Mt CO_2-e lower than the 2022 projections. Emissions are expected to be 1.5 and 0.8 Mt CO_2-e higher in 2030 and 2035, respectively, compared to previous estimates.

This uptick can primarily be attributed to higher levels of crop production and livestock activities than previously anticipated. The overall declining trend, in contrast to previous BAU emissions projections, can be partially attributed to forecasted drier conditions, resulting in lower forecasts for certain crop production and livestock activities in the short term. This trend in later years of the projection reflects historical activity patterns, as discussed in the sections on livestock and crop activities.

There is less abatement projected under PIPAP in the 2023 projections update, due to updated modelling commissioned for changes to the programs funding profile. Under current policy projections, emissions are between 1.9 and 2.5 Mt higher in 2030 and 0.6 to 1.4 Mt higher in 2035, compared with the last projections update. Further discussion is provided in subsequent sections.

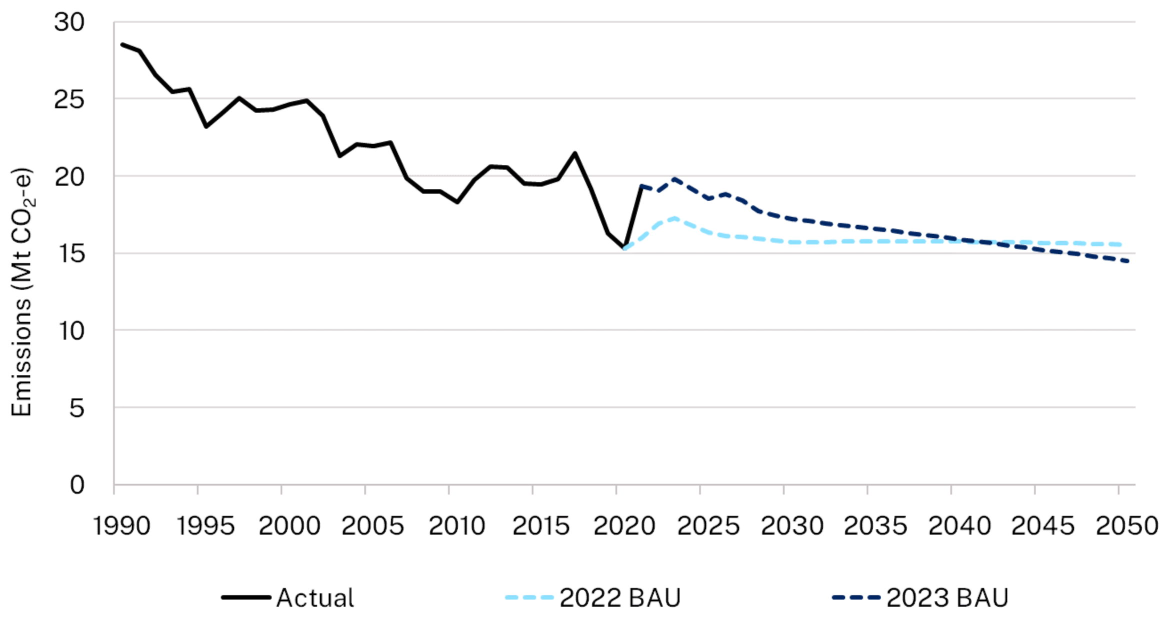

Figure 35 **Comparison of 2022 and updated 2023 business as usual (BAU) emissions projections for the agriculture sector**

Methodology and assumptions

Business as usual methodology and assumptions

Emissions from the agriculture sector are projected using bottom-up modelling. The model used is generally similar to the model developed by Cth DCCEEW (2023h) for the years where outlook data is available from the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), the Organisation for Economic Co-operation and Development (OECD) and Food and Agriculture Organization of the United Nations (FAO) (OECD 2022). The emission commodities/sectors and subsectors covered in the *National inventory report 2021* (Cth DCCEEW 2023e) are included in this agricultural projection (Table 35).

Table 35 **Emission subsectors included in the projections for each agricultural commodity**

Sector	Emissions subsectors included
Sheep	Enteric fermentation, manure management, agricultural soils
Dairy	Enteric fermentation, manure management, agricultural soils
Grain-fed beef	Enteric fermentation, manure management, agricultural soils
Grazing beef	Enteric fermentation, manure management, agricultural soils
Pigs	Enteric fermentation, manure management
Other animals	Enteric fermentation, manure management, agricultural soils
Crops/pastures	Agricultural soils, field burning of agricultural residues, rice cultivation

Sector	Emissions subsectors included
Lime and urea	Liming and urea application
Fertilisers	Agricultural soils

Livestock and crop activities

The data and methods used to project livestock and crop activities to 2050 are summarised in Table 36. NSW activity was projected using predominantly the commodities outlook data from ABARES (ABARES 2023a,b). The outlook data from ABARES provided crop and livestock forecasts to 2028. This was supplemented with outlook data from OECD-FAO (OECD 2022), which provided selected crop outlooks to 2031. The key assumptions and underlying trends that drive the forecasts are documented in relevant ABARES agricultural commodities reports (ABARES 2023a,b) and *OECD-FAO Agricultural outlook 2022–2031* report (OECD 2022). Historical activity data (1990–2021) was based on the *National inventory report 2021* (Cth DCCEEW 2023e).

The outlook data provided by OECD-FAO and ABARES were aggregated at national level. National outlook activity was apportioned to NSW by applying the ratio of NSW to Australia activity based on the activity data from the latest *National inventory report 2021* (Cth DCCEEW 2023e). This assumed that NSW projected activity is proportional to its baseline contribution to Australia's total activity for the commodity.

For beef cattle, 5% of the total ABARES projected livestock number was partitioned to feedlot cattle based on historical ratios of annual feedlot to grazing beef cattle numbers. For pigs, only sow numbers were projected by ABARES. As the ratio of the subclasses of pig were relatively stable over time, it was used to estimate the total number of pigs. The total number of pigs was a multiple of 10.7 to the number of sows.

Table 36 Data and method used to project agricultural activity to 2050

<table>
<tr><th>Sector/commodity</th><th>Available outlook years</th><th>Remaining years</th></tr>
<tr><td rowspan="2">Beef cattle – pasture, dairy cattle, sheep, wheat, cotton, sorghum, barley</td><td>ABARES (2023a) for 2022–2024</td><td rowspan="3">Regression to the long-term (2010–2021) mean</td></tr>
<tr><td>ABARES (2023b) for 2025–2028</td></tr>
<tr><td>Pig</td><td>ABARES (2023b) for 2022–2028</td></tr>
<tr><td>Beef cattle – feedlot</td><td>ABARES (2023b) for 2022–2028</td><td>Wood et al. (2021) growth rates</td></tr>
<tr><td>Rice, sugar cane, oilseeds, maize</td><td>OECD (2022) to 2031</td><td>Regression to the long-term (2010–2021) mean</td></tr>
<tr><td>Other animals, other crops, pasture, and inorganic fertilisers applied to pasture and horticulture</td><td colspan="2">No outlook data but historical activity data are available. Apply regression to the long-term (2010–2021) mean</td></tr>
</table>

Post-outlook years, a linear regression to the long-term average (2010–2021) was applied. An exception was made for feedlot cattle, which was projected to increase as farmers seek a more drought-resilient approach to beef cattle production (DISER 2021b). For feedlot cattle, we applied beef cattle growth rates for 2029–2050 from Wood et al. (2021).

Emission intensity by subsector and commodity

An emission intensity was calculated for each subsector using emissions for the subsector divided by the activity for the commodity/sector for the year 2021. The emission intensity of each subsector is initially assumed to remain constant, for example, emission intensities for livestock subsectors were calculated as:

$$EI_{livestock} = \frac{E_{subsector}}{N}$$

where:

$EI_{livestock}$ = emission intensity for livestock

$E_{subsector}$ = emissions from agricultural soils, enteric fermentation, or manure management in 2021

N = number of livestock in New South Wales as reported in the State and Territory Greenhouse Gas Inventory (STGGI).

For crops, the emission intensity for each subsector by crop type was calculated as:

$$EI_{cr} = \frac{E_{subsector}}{Y}$$

where:

E_{cr} = emissions from cropping

$E_{subsector}$ = emissions from agricultural soils, field burning of agricultural residues, or inorganic fertiliser (this applies only to sugar cane and cotton, where crop-specific emissions data are available)

Y = yield for crop in New South Wales as reported in STGGI.

Emission intensities were held constant for all commodities in the BAU projections except cattle and sheep, which were reduced by 10% to reflect recent policy directions by major industry bodies, such as Meat and Livestock Australia, the National Farmers Federation, and Dairy Australia.

Emissions by subsector and commodity

Emissions were calculated by multiplying the projected activity and emission intensity for each subsector:

$$E_{ts} = a_t * EI_s$$

where:

E_{ts} = emissions from subsector at time t

a_t = activity from commodity or sector at time t

EI_s = emission intensity of a subsector in 2021.

For urea application and inorganic fertiliser applied to irrigated and non-irrigated crops, we assumed the use of fertilisers for these sectors will change in response to crop productivity. To estimate these changes, we focused on 5 key crops — wheat, sugar cane, barley, rice and sorghum — that collectively contribute to 73–85% of crop yield in New South Wales. These crops were used as a proxy to estimate the rate of change for emissions related to urea application and inorganic fertiliser applied to irrigated and non-irrigated crops. In essence, we assumed that the rate of change in emissions from the latest inventory year for urea application would mirror that of these 5 key crops.

The emissions for each commodity or sector are the sum of its emissions subsectors:

$$E_t = \sum_s E_{ts}$$

where:

E_t = total commodity or sector emissions at time t

E_{ts} = emissions at time t from each sector.

Historical activity data were unavailable for liming, sewage sludge applied to land, and mineralisation due to loss of soil carbon. For these sectors, it was assumed that emissions will return to the long-term (2010–2021) average in the absence of suitable proxies.

Gaps and limitations

The impact of climate change on agricultural commodities in New South Wales is difficult to account for due to the lack of spatially explicit emissions and activity time-series data. Without such data, it is not possible to analyse the regional impact of climate on agricultural productivity. Additionally, production may move to areas where conditions may be more variable. Currently, these impacts are indirectly accounted for through setting the long-term average emissions or activity as represented by the years 2010–2021. This decade recorded substantially more temperature and rainfall extremes than the preceding decade (BOM and CSIRO 2022) and includes an agricultural drought period.

Livestock-related emissions accounted for 82–94% of the NSW agricultural emissions from 1990–2021, therefore, accurate livestock projections, particularly for sheep and beef cattle, are important for projecting agriculture emissions. Given the absence of available data, peer reviewers were accepting of the linear projection of agricultural activities beyond 2028, but highlighted it as an area for further analysis when preparing updated projections.

Current policy assumptions

The current policy projections for agriculture assume the NSW Government will play a significant role in supporting supply chains (where necessary) and expanded access of NSW farmers to environmental markets and environmental, social and governance investment streams through PIPAP. Actions under stages 2 and 3 of the Net Zero Plan under committed NSW Climate Change Fund funding is also included. Based on the extent of emissions in the agriculture sector and remaining opportunities for abatement, the projections assume that about 30% of the funding over 2030–2050 would be invested in driving further reductions in this sector. Support for abatement within the agricultural sector is assumed to leverage existing federal government focus and funding and corporate commitments.

Enteric CH_4, primarily from cows and sheep, represents the largest source of emissions within the Intergovernmental Panel on Climate Change (IPCC) agriculture sector (70% of emissions in 2021). A major agricultural producer with large livestock herds, New South Wales is considered to have the market scale necessary to accelerate the commercialisation and adoption of low emissions technologies and practices (OCSE 2023). There are opportunities to reduce these emissions through activities such as improved herd management, feed additives and vaccines, however, some options are not commercially available and there has been limited uptake of existing Emissions Reduction Fund methods (CCA 2020). With more countries implementing emissions reduction strategies for their livestock herds, if New South Wales marketed low emission livestock products (e.g. meat, dairy and wool), this would provide a competitive advantage for NSW farmers in high value exports (OCSE 2023).

Almeida and Hegarty (2021) assessed strategies for abating enteric CH_4 emissions of relevance to New South Wales. This detailed study found significant, feasible potential to abate enteric CH_4 emissions from feedlot and dairy cattle through dietary modification, with lower levels of abatement for other cattle and sheep. The study concludes feasible abatement in 2030 of up to 50% for feedlot and dairy cattle, and up to 12% for grazing beef with moderate to high confidence depending on the dietary supplement used. This assessment considered ease of implementation, commercial availability, abatement effectiveness and adoption rates; and assumed a market incentive that removes cost barriers and the removal of any regulatory barriers where these exist.

The 2022 projections for New South Wales assumed an abatement efficiency of 81% for dietary modification in dairy cattle, based on the upper end of the estimated feasible abatement range (Waters et al. 2020; Ridoutt et al. 2022). The same abatement efficiency was assumed for the updated PIPAP modelling in 2023 and adopted for the abatement as originally designed scenario. However, the independent peer review classified this assumption as overly optimistic and not supported by evidence.

Therefore, to account for uncertainty in abatement that may be able to be achieved in this sector, the 'abatement as currently tracking' uses a technical abatement potential for dietary modification at the lower end of the reported range in the literature (30%), with a more cautious adoption rate of 60% by 2030 also assumed (i.e. 60% adoption by 2030 with 30% abatement efficiency).

Considerations for projection updates

Future projection updates will incorporate the most recent outlook data for agricultural commodities and refine projections for the period beyond 2028, taking into account factors such as holding capacities, arable land limitations and impacts of climate change. Efforts will be made to enhance the method used for long-term projections to reduce sensitivity to annual fluctuations in past emissions. Additionally, modelling updates will integrate additional analysis for NSW Government programs, taking into consideration new information on emerging technologies and the increasing commitments of corporations to reduce carbon emissions.

Land use, land-use change and forestry

The land use, land-use change and forestry (LULUCF) sector accounts for emissions and removals from several sources, including forest land, cropland, grassland, wetlands, other land and settlements. It includes emissions from events of land clearing, timber harvesting, wildfires and prescribed fires. It also includes removals by harvested wood products and forest growth from the aforementioned events. Management activities on cropland and grassland that contribute to emissions and removals are also accounted for in this sector.

Land-use classification within the LULUCF sector is derived from Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) catchment-scale land-use data. 'Forest land' is defined as having trees with a minimum height of 2 m, crown canopy of at least 20%, and coverage of not less than 0.2 ha (DISER 2022c). Forest land excludes woody horticulture, which is classified as cropland under this sector.

Land utilised for continuous cropping and crop–pasture rotation forms part of the cropland category. LULUCF subcategory 'cropland remaining as cropland' does not account for non-carbon dioxide (CO_2) emissions; these emissions are accounted for in the agriculture sector (DISER 2022c).

Grassland includes shrubs of woody vegetation (sub-forest forms) and areas of varying grassland ecosystems (type, climate, management) (DISER 2022c).

Residential and industrial infrastructure, towns, cities and road networks are included in the settlements classification (DISER 2022c).

Wetlands are based on data from the Bureau of Meteorology Australian Hydrological Geospatial Fabric (BOM 2022) and Directory of Important Wetlands in Australian (Cth DCCEEW 2021); these being areas of perennial lakes, reservoirs, swamps, major water courses and existing wetlands (DISER 2022c).

Other land relates to areas where the above land-use classification cannot be met and includes areas such as bare soil and rock (DISER 2022c).

Summary of the emissions trends

Business as usual (BAU) emissions projections for the LULUCF sector are shown in Figure 36. Under the BAU scenario, the emissions sink is projected to decline over the long term. Emissions from the LULUCF sector are −4.0 Mt CO_2-e for 2021, with the net sink projected to only marginally increase to −4.5 Mt CO_2-e by 2030 and −5.17 Mt CO_2-e in 2035, based on the Commonwealth's 2023 projections for Australia (Cth DCCEEW 2023g).

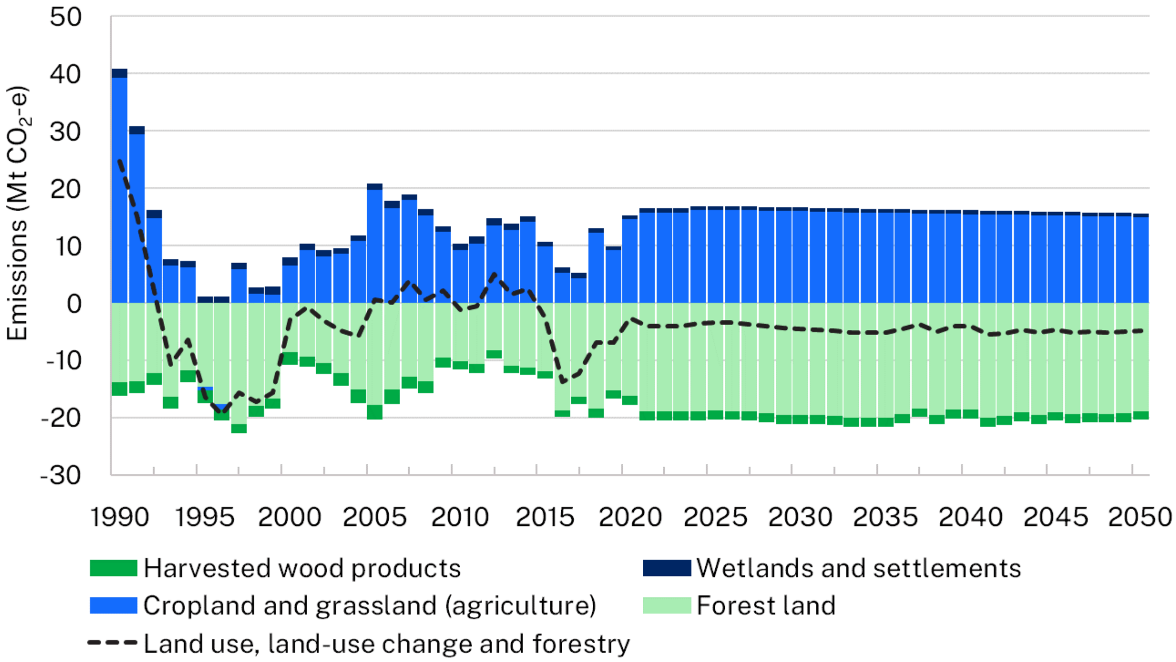

Figure 36 **Land use, land-use change and forestry emissions and sequestration showing inventory estimates (1990–2020) and business as usual (BAU) emissions projections (2021–2050)**

Current policy

Abatement in this sector is projected to come from planting and soil carbon activities supported by the Primary Industries Productivity and Abatement Program (PIPAP), the *NSW Blue Carbon Strategy 2022–2027* (DPE 2022b) and the NSW National Parks and Wildlife Service *Carbon positive by 2028* plan (NSW Government 2022b). Other related policies that are assumed to contribute through reduced clearing include the *Land Management (Native Vegetation) Code 2018* and the *NSW natural capital statement of intent* (NSW Government 2022c).

The potential carbon sequestration within the LULUCF sector achievable under the PIPAP has been revised from what was projected based on the early program design. Updated modelling has been completed in 2023 for focus area 2 (building critical mass and capacity), to account for changes to the budget profile, realised co-investment and changes to projected Australian carbon credit units (ACCUs) price (GHD 2023). This downgrades the potential abatement under PIPAP, for example in 2030, potential abatement drops from 4.5 Mt CO_2-e to 0.2 Mt CO_2-e, primarily due to less assumed funding.

To account for uncertainty in the amount of abatement that may be able to be achieved in this sector, 2 abatement scenarios are presented. Under the abatement as originally designed scenario, sequestration within the LULUCF sector is needed on par with PIPAP original abatement projections. There is an opportunity for enhanced sequestration in this sector due to the potential increase in demand for ACCUs under the Safeguard Mechanism reforms, leading to an opportunity for New South Wales to develop premium carbon and environment markets and attract investment from within and outside the state.

While the Commonwealth's land sector projections already account for forecast ACCU supply from increased demand, the Commonwealth's emissions projections also assume higher levels of onsite abatement for NSW facilities. Therefore, ACCU supply forecasts do not necessarily account for higher demand associated with less onsite abatement assumed in NSW's emissions projections. For New South Wales to remain on track to achieving its targets, any shortfall between ACCU supply forecasts for the land sector and NSW's requirements under Safeguard Mechanism (excluding assumed onsite abatement) would need to be offset in New South Wales. This assumption would result in an additional 3.6 Mt CO_2-e of abatement within the land sector in 2030, as shown in Figure 37, effectively replacing the reduced abatement from PIPAP in this abatement as originally designed scenario.

There is, however, no current regulatory requirement for NSW facilities to offset within New South Wales, therefore under the cautious 'abatement as currently tracking' scenario, no additional abatement is assumed for Safeguard Mechanism, other than what is already accounted for in ACCU supply forecasts or onsite abatement. Under the 'abatement as currently tracking' scenario, there would be less than 1 Mt CO_2-e in 2030, shown in Figure 37.

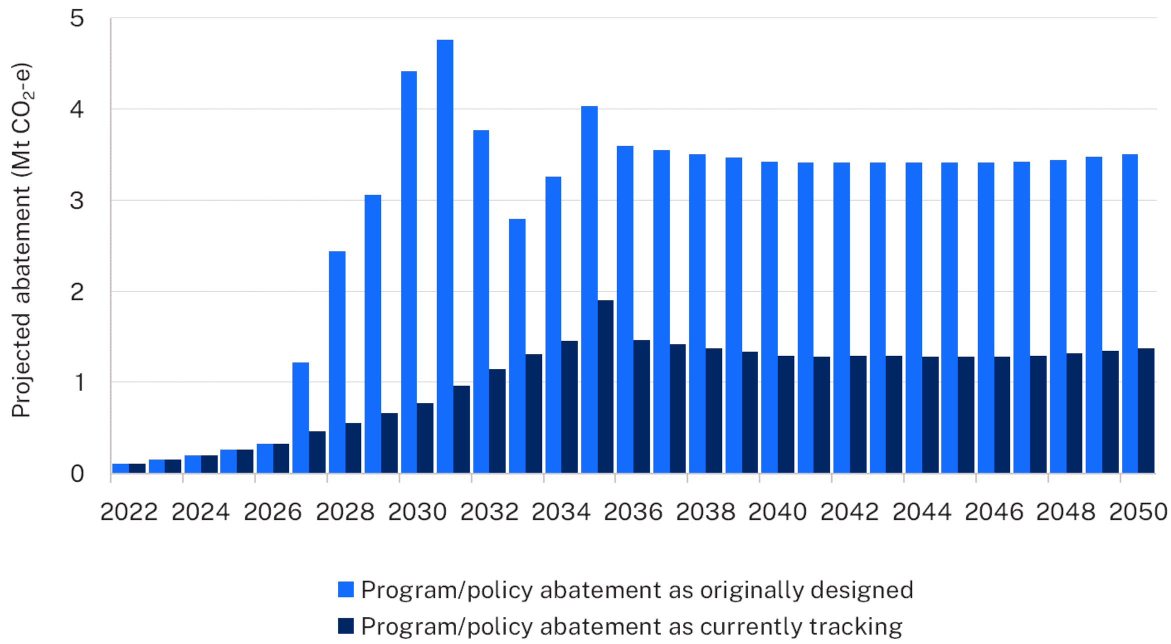

Figure 37 **Enhancement of land use, land-use change and forestry sector carbon sequestration projected to be achieved under current policy scenarios (2022–2050)**

The resultant current policy projections for this sector compared to BAU projections are shown in Figure 38. The current policy projections increase the LULUCF sink, with the potential benefit from additional offsetting requirements under Safeguard Mechanism reforms shows in the lower abatement as originally designed projection line.

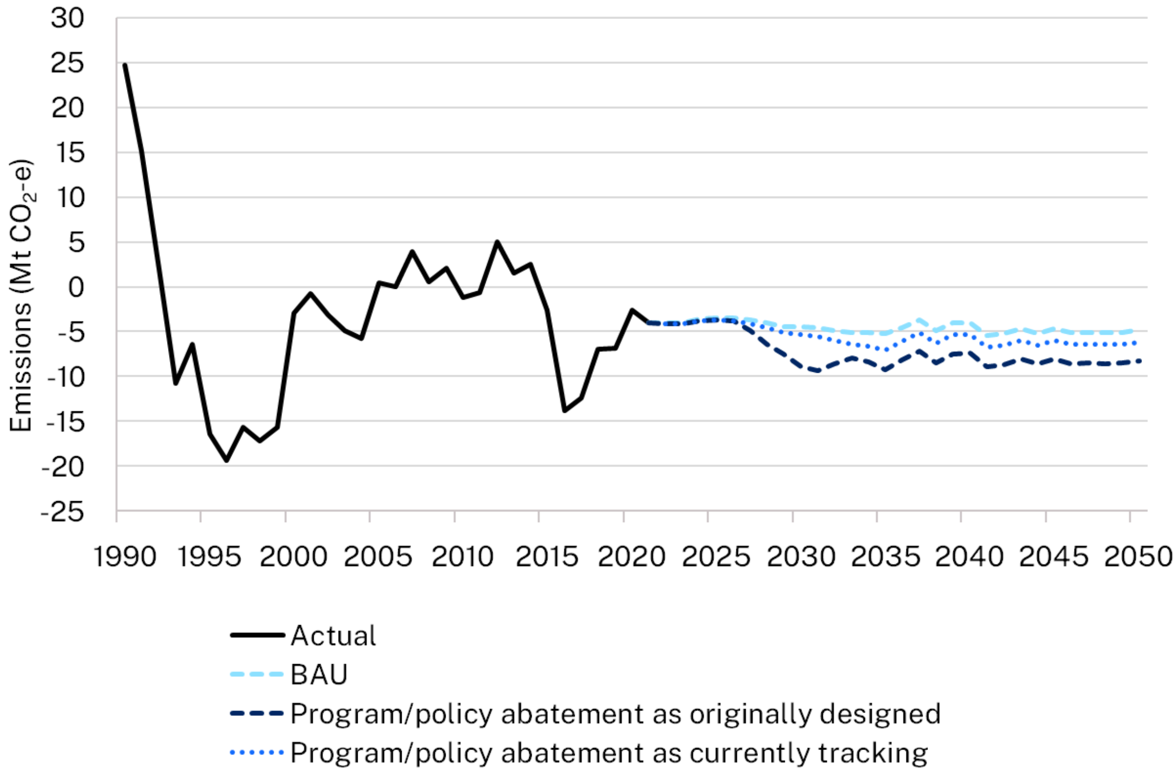

Figure 38 **NSW land use, land-use change and forestry sector emissions as inventoried (1990–2021), with business as usual (BAU) and current policy projection range (2022–2050)**

Summary of changes in emissions since last year's projection update

Compared with the 2022 BAU projections, LULUCF is projected to be a smaller sink before 2028 and a larger sink after 2028 in the 2023 BAU projections. The LULUCF sink is 0.8 Mt CO_2-e larger in 2030 and 2.2 Mt CO_2-e larger in 2035 in the 2023 projections.

As described above, there is less abatement projected under PIPAP in the 2023 projections update, balanced by additional abatement assumed under Safeguard Mechanism if offsetting in New South Wales can be prioritised.

Under current policy projections, the difference from last year's projections is between −0.2 to +3.4 Mt in 2030 and −1.7 to +0.4 Mt in 2035, with the range reflecting whether additional offsetting under Safeguard Mechanism occurs or not.

Methodology and assumptions

Business as usual methodology and assumptions

LULUCF sector emission estimates for New South Wales were provided by the Commonwealth, based on their modelling for Australia's emission projections. Projections are provided up to and including 2035, based on modelling using the Full Carbon Accounting Model (FullCAM, Cth DCCEEW 2023e). FullCAM is a modelling framework comprised of integrated sub-models for estimating impact to carbon stocks and emissions under varying land use, land-use change and forestry management practices and temporal conditions. Detailed methods are described in national inventory reports (Cth DCCEEW 2023e,f; DISER 2022b,c,d).

For projections post 2035, subsector emissions/sequestration were linearly forecast to 2050 for all subsectors except forest land. Projections for forest land were estimated based on the assumptions that no significant changes in forest land area and forest management (and events) occur post 2035. In addition, linear regression was used to model annual variations of emissions from forest in response to the changes in annual rainfall for the period 2035–2050. The New South Wales and Australian Regional Climate Modelling project version 1.5 (Nishant et al. 2021) was used for estimating the variations in future climatic conditions for New South Wales.

Activity data

The harvesting activity in native forests, including multiple-use forests and private native forests, is a key driver of carbon flux. Over recent years, harvesting in the native forest sector has reached historically low levels (Gavran 2020) (Figure 39).

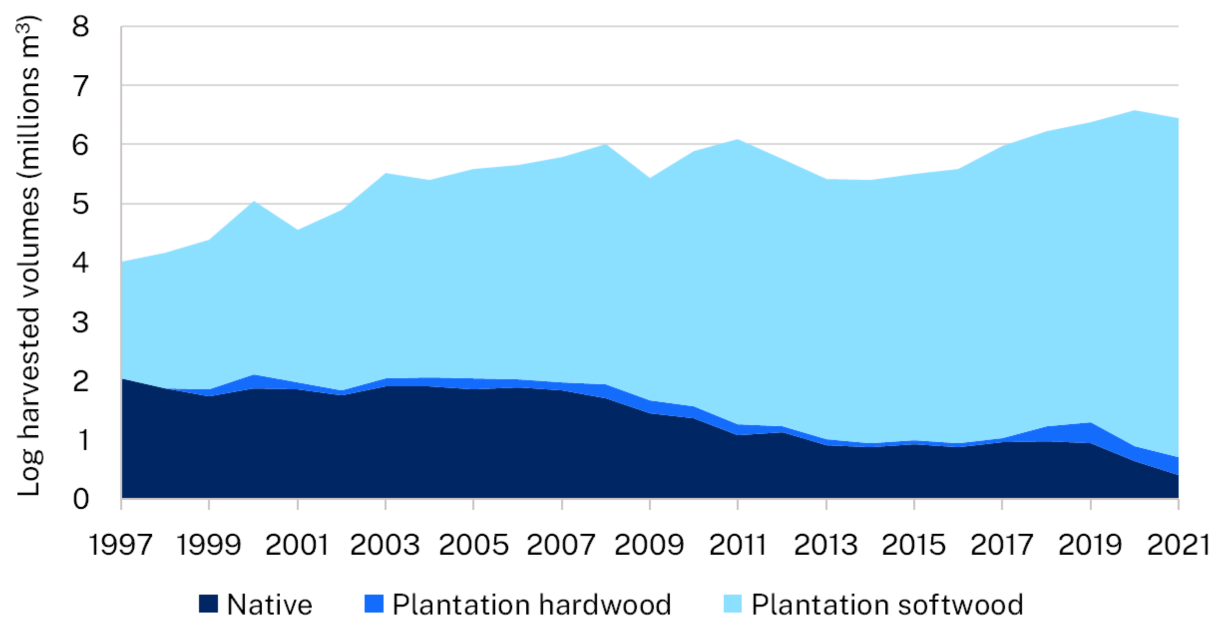

Figure 39 **Historical log harvested volumes from native forestry and plantations (1997–2020)**

Plantations included within forest land include softwood and hardwood plantations. The log harvest volumes from softwood plantations have increased since late 1990s, whereas native and hardwood plantations have steadily declined and remained relatively low over the same period (Figure 39). The maximum estate size of plantation was reached in 2016 at 394,400 ha (Gavran 2020).

Based on analysis by the Australian Government, most forest conversion activity in Australia is for the purpose of maintaining pastures for grazing activities (Cth DCCEEW

2022c). Some forest conversion occurs to support cropping as well as smaller land-use conversions for settlements, infrastructure and reservoirs. The land clearing projection was developed based on recent trends in land clearing activity for grassland and cropland. Most clearing activity in Australia is associated with the re-clearing of regrown forest vegetation (Cth DCCEEW 2022c) and reflects economic considerations by famers and landholders and livestock markets. Land clearing restrictions have seen primary forest conversion stabilise at low levels over the past decade compared to the historic record (Figure 40).

Primary forest conversion is assumed to remain at low levels based on the historic record, and regrowth and re-clearing activity is assumed to respond to changes in the number of livestock based on projections for the agriculture sector (Cth DCCEEW 2022c). A 10-year cycle of re-clearing of regrowth is applied. The rate of re-clearing is relatively stable based on historical data, which indicates a cyclical need to re-clear areas on the fringe of agricultural regions where adjacent forests contribute to forest regeneration on such fringe land (DISER 2021b).

For agricultural land (cropland and grassland), management practices and crop type are assumed to remain unchanged over the projection period. Activity levels are assumed to return to long-term averages (2010–2020) over the projection period (Cth DCCEEW 2022c).

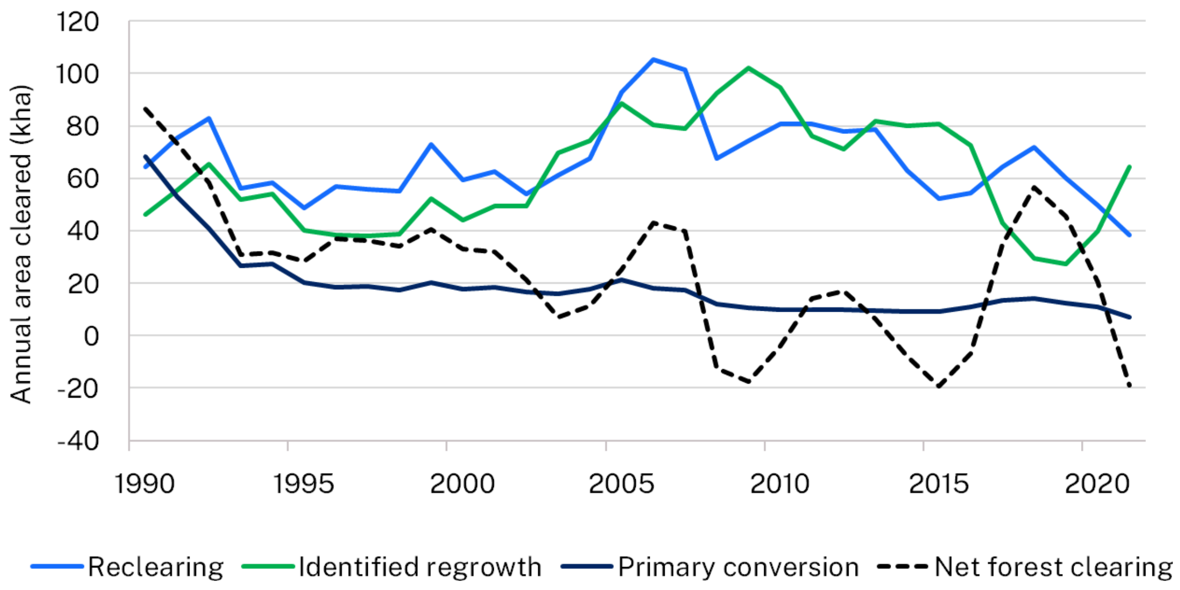

Figure 40 **Historical primary conversion, re-clearing and regrowth (1990–2020)**

For other land, including wetlands and settlements, activities are assumed to return to long-term averages (2010–2021) (Cth DCCEEW 2023e).

Harvested wood products are estimated as production plus imported materials minus exported materials (Cth DCCEEW 2023e,f). Activity from harvested wood products is projected based on forecast wood production and recycling rates (DISER internal analysis).

BAU projections take into account abatement under Australia's carbon crediting scheme (Cth DCCEEW 2022c).

Land clearing is a source of emissions within the LULUCF sector accounted for under 'land converted to other land use', including grasslands and croplands (agriculture), wetlands and settlements. Economic considerations are an important driver of this land clearing.

Carbon sequestration is predominantly due to forest land remaining forest land, which includes native forestry and pre-1990 plantations, and sequestration from regrowth occurring on land converted to forest land. In recent years, since 2012, sequestration has been greater than emissions, resulting in the LULUCF sector being a net sink of emissions. The shift of the LULUCF sector from a net source of emissions to a net sink contributes to reductions in the state's overall net emissions.

Beyond 2035, the projections for the subsectors, except forest land, are based on a 10-year linear trend with minimal change in emissions/net sink gain, where the average climate conditions are assumed. For the forest land subsector, sink size varies with the climatic conditions with the assumptions of no significant changes of clearing and regrowth post 2035. This assumption is made based on previous restrictions on land clearing and the dynamic balance between clearing and regrowth being reached post 2035.

Gaps and limitations

The current projections do not explicitly account for the impact of climate change on the emissions from land sector (except forest land subsector) in New South Wales. Some of these impacts are indirectly and partially accounted for through setting the long-term average activity as represented by the years 2010–2021. This decade recorded substantially more temperature and rainfall extremes than the preceding decade (BOM and CSIRO 2020) and included an agricultural drought period.

Current policy assumptions

The current policy projections for the LULUCF sector consider announced policies under stage 1 of the Net Zero Plan and related NSW Government actions (Table 5). This includes the PIPAP, the *NSW Blue Carbon Strategy 2022–2027* (DPE 2022b) and the NSW National Parks and Wildlife Service *Carbon positive by 2028* plan (NSW Government 2022b). The Safeguard Mechanism reforms are also assumed to enhance abatement opportunities in this sector.

As discussed previously, revised modelling for PIPAP downgrades the potential abatement under the program, for example in 2030, potential abatement drops from 4.5 Mt CO_2-e to 0.2 Mt CO_2-e, primarily due to less assumed funding. Sequestration opportunities were considered across all land tenures in New South Wales, including private farmland, public lands and Aboriginal-managed lands.

The Blue Carbon Strategy provides a roadmap to support blue carbon projects in NSW (DPE 2022b). Blue carbon is the term used to describe carbon captured and stored by marine and coastal ecosystems. Blue carbon ecosystems, which include seagrass, mangroves and saltmarsh, can store substantially more carbon per area than land-based forests and, if undisturbed, can store this carbon in soils for many years. Projects that restore blue carbon ecosystems, such as the reintroduction of tidal flows to restore coastal wetlands, can help deliver significant emissions reductions and may enable carbon credits to be earned. The revised abatement projections for PIPAP includes an existing project under the Blue Carbon Strategy, funded through PIPAP. This is currently the only abatement included in the projections for blue carbon.

The NSW National Parks and Wildlife Service has committed to being net zero and carbon positive by 2028, and the revised abatement projections for PIPAP includes abatement under the Koonaburra human-induced regeneration project.

Other policies addressing land management with implications for land sector emissions and sequestration include the *Land Management (Native Vegetation) Code 2018* (see DPE 2022c) and the *NSW natural capital statement of intent*. The 2018 Native Vegetation Code supports landholders to manage their land to ensure more productive farming methods and systems, while responding to environmental risks. Some clearing under the Native Vegetation Code will require land to be set aside, which will be listed in a public register. Higher impact clearing will require approval from a new Native Vegetation Panel, and landholders will be required to assess and offset the biodiversity impacts of approved clearing. Based on these policies, it was assumed that forest land clearing/re-clearing would reduce by 15% below 2011–2020 forest conversion rates by 2035.

Considerations for projection updates

Significant uncertainties exist in the modelled emissions and program abatement for the land sector. Efforts continue to refine, update and improve projections for the sector. Future projection updates will continue to include latest data and model improvements, including options to account for land clearing for cropping areas, settlements and wetlands and the use of Sentinel 1 and 2 remote sensing imagery for refined land-use classification. Further research into the sequestration potential for New South Wales may help refine future assumptions for abatement, while revised modelling for the market and industry foundations focus area of PIPAP is also expected in 2024.

Over the longer term, projection improvements will aim to include climate change projections within FullCAM modelling and soil carbon sequestrations for the land use change.

Waste

The waste sector includes emissions from solid waste disposal and treatment, and domestic, commercial and industrial wastewater treatment and discharge. Emissions from solid waste disposal are the largest source, contributing 76% of total waste emissions in New South Wales in 2021 (NSW State and Territory Greenhouse Gas Inventory [STGGI] data, 2023) and detailed emissions projections have been undertaken for this sector. Domestic wastewater treatment is the next largest source, contributing a further 13% of waste emissions in 2021. Industrial wastewater treatment accounted for about 8%, with biological treatment and incineration being minor sources (<3% of waste sector emissions).

Summary of the emissions trends

Business as usual inventoried emissions (1990–2021) and business as usual (BAU) emissions projections (2022–2050) for the NSW waste sector by subsector are shown in Figure 41.

Three-quarters of recent waste emissions are due to solid waste disposal, with much of the remainder from domestic and industrial wastewater. The decrease in past emissions was due in part to the use of landfill gas capture technology. This allows the gas to be used for power generation, transferred offsite or flared onsite, where the methane (CH_4) is combusted to carbon dioxide (CO_2), a much less potent greenhouse gas (GHG). The fall in emissions was also due to reduced waste generation per capita and increased recycling rates and diversion of waste away from landfills.

The step change in emissions for the projected future years is due to the department using the higher waste volumes from the NSW EPA's Waste and Resource Reporting Portal (WARRP) data as inputs into the solid waste projections and more detailed modelling of wastewater treatment works, as described in the previous section. Detailed modelling of wastewater treatment emissions in 2023 show that emissions projections from 2022–2050 for industrial wastewater are greater compared to the projections made in 2021.

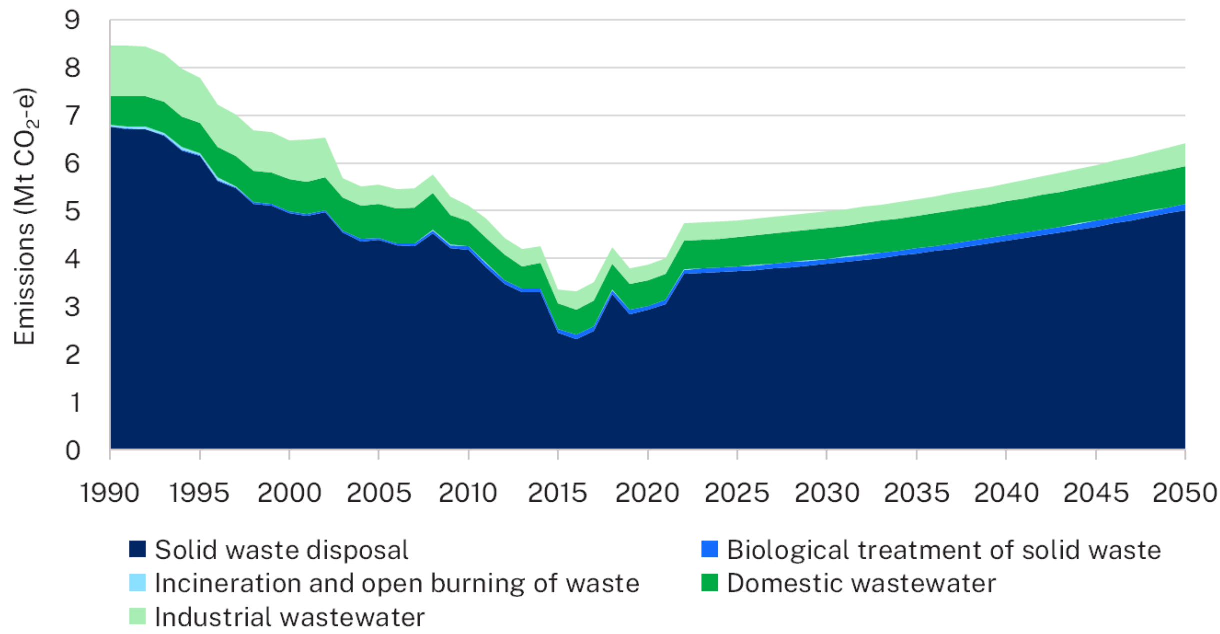

Figure 41 **Waste emissions by subsector showing inventory estimates (1990–2021) and business as usual (BAU) emissions projections (2022–2050)**

Current policy

For this sector, no difference is currently identified between the abatement as originally designed scenario and the 'abatement as currently tracking' scenario, therefore a single current policy projection is presented.

The abatement in the waste sector modelled to be achieved (as outlined in the assumptions above) within the 2023 projections is shown in Figure 42, with resultant current policy projections for this sector compared to BAU projections in Figure 43. The steep increase in abatement to 2035 is predominantly driven by an increase in CH_4 capture from solid waste to landfill disposal, from the current 39% to 75%, supported by the 50% reduction in food and garden organic waste to landfill by 2030. Beyond 2035, gas capture rates were modelled to remain constant (from 75 to 77%).

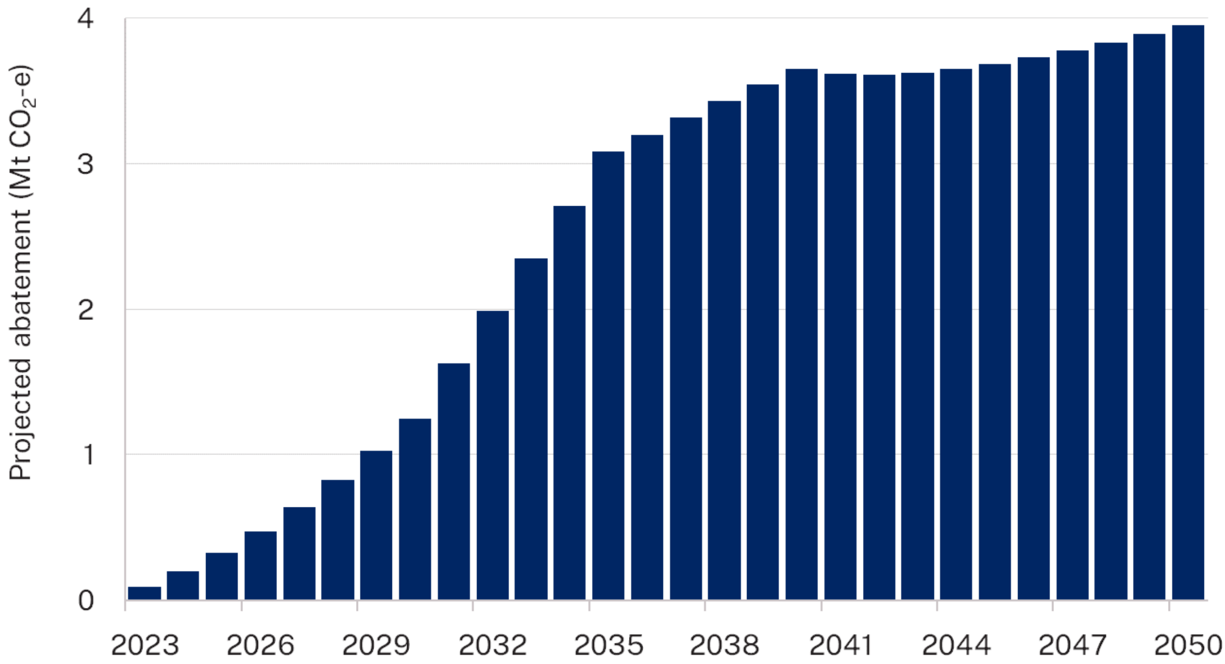

Figure 42 **Abatement of waste sector emissions projected to be achieved by Net Zero Plan stage 1 programs (2022–2050)**

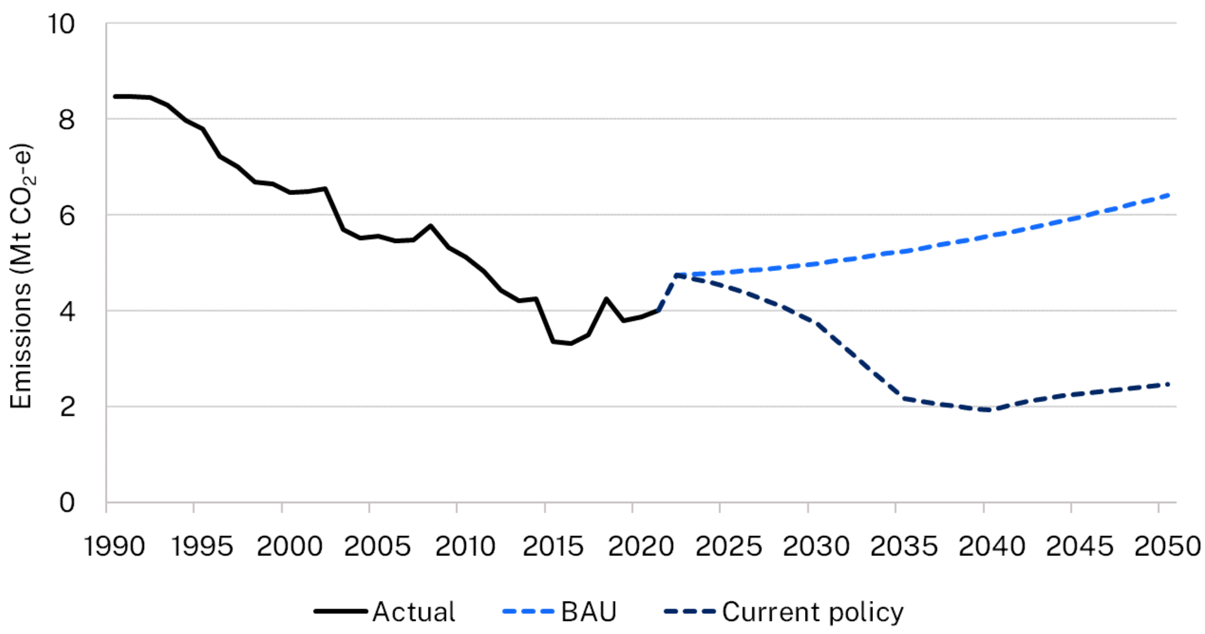

Figure 43 **NSW waste sector emissions as inventoried (1990–2021), with business as usual (BAU) and current policy projection (2022–2050)**

Inventoried emissions (1990–2021) and current policy emissions projections (2022–2050) for the NSW waste sector by subsector are shown in Figure 44. As noted for the BAU projections, the step change in emissions for the projected future years is due to the department using the higher waste volumes from the NSW EPA's WARRP data as inputs into the solid waste projections and more detailed modelling of wastewater treatment works. Past emissions reduced due to reduced waste generation per capita, increased recycling rates and the diversion of waste away from landfills. These trends are projected to be further supported under the *Waste and Sustainable Materials Strategy 2041: Stage 1, 2021–2027* announced in June 2021 (DPIE 2022b). Confirmed targets within the strategy related to implementing further landfill gas capture and requiring landfills subject to environment protection licences to be net zero, will be addressed in future projections.

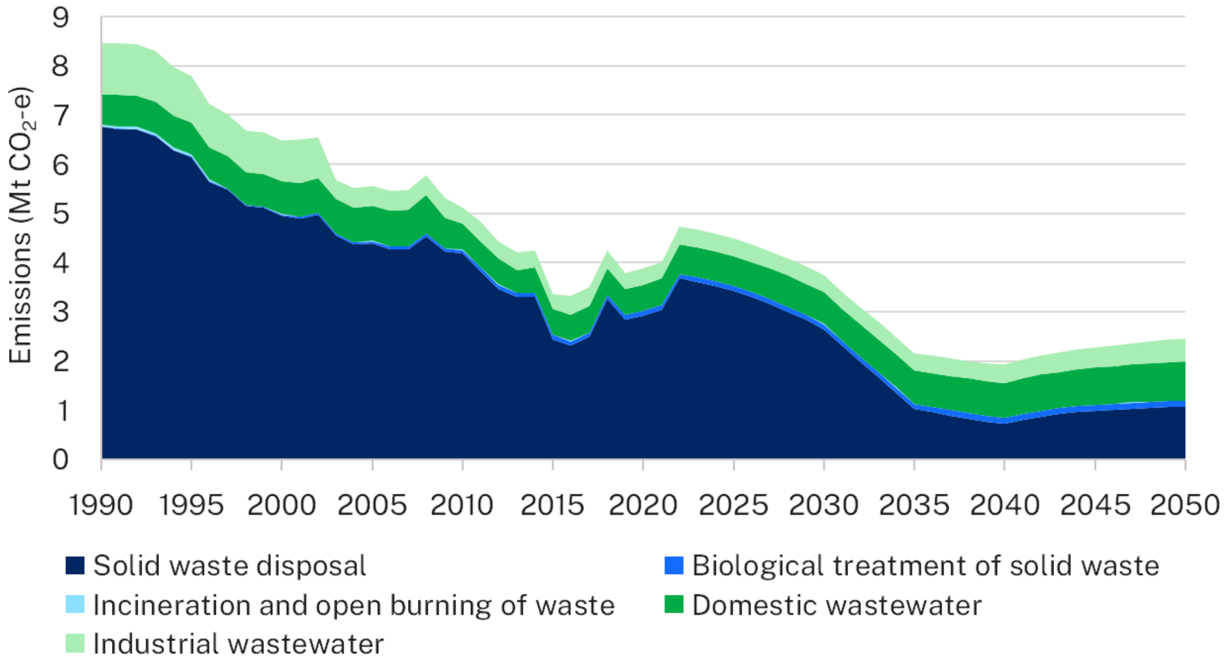

Figure 44 **Waste emissions by subsector showing inventory estimates (1990–2021) and current policy emissions projections (2022–2050)**

Summary of changes in emissions since last year's projection update

Emissions from the waste sector are projected to be higher than the previous update, driven primarily by changes in the solid waste subsector. The increase is partly due to an increase in the 4-year NSW Treasury forecast for the gross state product, leading to an increase in the tonnes of waste from the commercial and industrial (C&I) streams projected to be disposed of at landfill sites.

The biggest influence on BAU projections, however, is the significant decrease in landfill gas capture rates projected beyond 2021–22. In the current update, landfill gas capture dropped from 46% in 2021 to 39% in 2022. The methodology discussed below was used to project the CH_4 capture efficiency per landfill for the period 2022–23 to 2049–50, resulting in lower overall gas capture for that period.

Thus, considerable effort will be required in landfill gas capture efficiencies if noteworthy reductions are to be made in the waste sector.

Methodology and assumptions

Business as usual methodology and assumptions

Solid waste disposal

This section addresses emissions generated from the disposal of solid waste to landfill from domestic, commercial and industrial sources. Emissions are predominantly CH_4, generated from the anaerobic decomposition of the organic matter. The NSW Net Zero Plan includes a target of net zero emissions from organic waste by 2030.

The BAU emissions from landfilled solid waste considers the projected growth in waste without additional abatement apart from gas capture technology and waste diversion and recycling programs already in place. The growth in waste is driven by population and economic growth.

Modelling approach

The method for calculating solid waste to landfill emissions is based on the formula:

$$E_{SW} = i + b + \left(CH_4(g) - CH_4(c)\right)$$

where:

E_{SW} = solid waste emissions

i = emissions from solid waste incineration

b = emissions from biological treatment

$CH_4(g)$ = solid waste CH_4 generated

$CH_4(c)$ = solid waste CH_4 captured.

According to the NSW STGGI data over the period 2015–2021, emissions from incineration and biological treatment of waste accounted for 0.1% and 3% of total waste sector emissions, respectively. Detailed modelling was therefore not done for these sources.

The method for calculating GHG emissions is based on a first-order decay model, in particular the Clean Energy Regulator's Solid Waste to Landfill model (CER 2023). This requires knowledge of the annual mass of waste deposited to landfills, the split in waste streams (i.e. % municipal solid waste [MSW], % commercial and industrial [C&I] and % construction and demolition [C&D]) and the mixture composition of these streams in terms of % food, % garden, % wood, % paper, % nappies, % sludge, % rubber, % leather and % inert waste.

The modelling relies on historical waste disposal data provided by Cth DCCEEW (formerly Department of Industry, Science, Energy and Resources [DISER]) and more contemporary data from the NSW EPA's WARRP (EPA 2023c), noting that detailed individual landfill data is strictly confidential. It also relies on Cth DCCEEW's estimates of gas capture (i.e. transfer of landfill gas off site for power generation, landfill gas flaring or landfill gas captured onsite) at each landfill site.

Cth DCCEEW has gathered waste disposal data for 26 specific landfills in New South Wales, most of which are currently in operation. Some of these landfills are closed but continue to emit CH_4. Most of the landfill data post-2009 has been captured from National Greenhouse and Energy Reporting Scheme (NGERS) reporting, but pre-2009 data has been captured from other unspecified sources via the Cth DCCEEW. The landfills are relatively large and most currently report under NGERS, having triggered the NGERS facility GHG emissions threshold. The modelling is based on the approach that a small number of landfills are responsible for the bulk of waste disposal in New South Wales and hence generation of GHGs. The WARRP data shows that the 27 large landfills are responsible for 59% and 63% of waste disposed in New South Wales in 2020–21 and 2021–22, respectively. The modelling assumes no new landfills, and that the 26 landfills listed will continue to operate out to 2050.

For the remaining smaller landfills (about 270 landfills according to recent NSW EPA WARRP data), Cth DCCEEW's approach is to lump these landfills together under the name 'residual NSW'. These smaller landfills do not produce sufficient emissions individually to trigger the NGERS facility reporting threshold, therefore, to model emissions from these smaller landfills the waste disposal tonnages are aggregated and modelled as one facility. For these smaller landfills data for individual facilities are not available. Cth DCCEEW has provided an estimate of landfill gas captured for 'residual NSW', and in 2021–22 the capture efficiency was 28%.

Data limitations and quality

Data limitations and factors affecting the data quality are:

- Most local councils are not constitutional corporations and therefore do not report under NGERS. The last data captured from councils was in 2013 under the former carbon pricing scheme. Thus, Cth DCCEEW does not have access to recent council landfill disposal data and hence their GHG estimates are unknown.
- Cth DCCEEW excludes virgin excavatable natural materials from their inventories. This term refers to quarried natural materials such as clay, gravel, sand, soil or rock fines, which are largely inert. Thus, there are significant discrepancies in the overall waste disposal data reported by Cth DCCEEW and the NSW EPA WARRP. Over FYs 2015–2020, Cth DCCEEW reported total waste disposed in New South Wales was 1.5–2.0 Mt lower than reported under the NSW EPA WARRP.
- Data reported under the NSW EPA WARRP only extends back to 2015–16. First-order decay modelling based on this data alone is not possible. According to the Intergovernmental Panel on Climate Change (IPCC), to use a first-order decay model to calculate landfill gas emissions for a landfill to reasonable accuracy, 3–5 half-lives of data are required (IPCC 2000). As an example, the decay rate, *k*, of food in New South Wales, assumed to be in a mostly dry temperate climate, is 0.06 p.a. giving a half-life of 12 years (noting that $t_{1/2} = \ln 2/k$); therefore 36–60 years of landfilling tonnage and composition data would be needed.

- The WARRP data do not include the age of the landfill, therefore, attempting to estimate the age and deposition history of a landfill can lead to large errors in contemporary landfill GHG emissions.
- The WARRP data do not collect landfill gas capture information.
- The landfill histories for the 26 specific landfills (27 including residual NSW) in the Cth DCCEEW dataset cannot be verified due to lack of historical record keeping and data availability.

Activity data inputs for GHG emissions projections

- Cth DCCEEW historical (FYs 1940–2014) waste stream data (i.e. tonnes of MSW, C&I, and C&D) are from the Cth DCCEEW solid waste spreadsheet model. FYs 2015–2022 use the NSW EPA WARRP data.
- Waste disposal projection data beyond 2021–22, use assumptions outlined in the department's Research and Insight Team's Waste Generation Model (summarised below). Note that the projected solid waste disposal tonnages from the Waste Generation Model (top-down perspective) do not exactly equal the projected solid waste disposal tonnages when the totals for individual landfills are summed (bottom-up perspective). This is due to limited information being available on the growth rates in waste tonnages disposed in individual landfills.
- Cth DCCEEW historical gas capture data (FYs 1940–2020) are from the DCCEEW solid waste spreadsheet model.
- Gas capture beyond 2021–22, uses a similar methodology to that outlined in the *Emissions projections from the waste sector* report prepared by Blue Environment (2019). The annual CH_4 capture efficiency per landfill (i.e. CH_4 captured (t CO_2-e)/ CH_4 generated (t CO_2-e)) is calculated according to the formula:

  CH_4 capture efficiency t = CH_4 capture efficiency (t–1)(1 + growth rate), where the growth rate = 0.25% p.a.

  The CH_4 capture efficiency in 2018–19 (obtained from Cth DCCEEW's dataset) is the initial value for gas capture, that is, the (t–1) value.
- Given the complexity of forecasting the change in waste stream mixes at each landfill, they are held constant at 2017–18 values (provided by Cth DCCEEW), that is, the % food, % garden, % paper, % wood, % textiles, % sludge, % nappies, % leather and rubber and % inert in the MSW, C&I and C&D wastes are held constant.
- For years 2022–23 out to 2049–50 the WARRP waste data are projected according to the NSW EPA's Waste Projection Model (v1.7) assumptions:
  - For MSW, this means a decrease of 1.52% between 2021–22 and 2022–23, and beyond a 0.4–1.1% (average 1.0%) increase p.a. in waste mass in line with projected growth in NSW population to 2041 (DPE 2022g). To 2050, the rate of increase is held constant at the 2041 value of 0.9%.
  - For C&I waste, the rate of increase is in line with the projected increases in gross state product (average 2.3% p.a. from 2023–2050).
  - For C&D waste, the rate of increase is in line with projected increases in building activity, an average of 1.8% from 2021–2041. These forecasts were

based on a combination of historical gross fixed capital formation – dwelling and non-dwelling construction for NSW (ABS 2020b), and NSW Treasury forecasts for construction to 2028. A long-range growth rate of 1.9% was applied from 2032 and held constant to 2050.

Business as usual projections

The BAU scenario takes the department's population and economic growth rate projections as the basis for the GHG emissions projections from 2023–2050. Modest improvements in gas capture rates as per Cth DCCEEW projections are assumed, based on the Blue Environment (2019) methodology.

The department's version of the Clean Energy Regulator's Solid Waste Calculator is used to model CH_4 generated per landfill in units t CO_2-e p.a. based on historical and projected waste deposition data and the waste mix information for each of the 26 individual landfills and 'residual NSW'. All landfills are considered to be in temperate (dry) regions except for one landfill in the Wollongong local government area and 'residual NSW', which were assumed by Cth DCCEEW to be temperate (wet).

To calculate the 'residual NSW' waste disposal for 2015–16 to 2021–22, WARRP data were used, with all waste disposal summed across the approximately 300 landfills in New South Wales and the waste disposed of the 26 landfills that are individually modelled subtracted. Cth DCCEEW waste mix percentages as at 2017–18 were adopted and held constant to 2050.

The annual CH_4 captured, flared or transferred (units t CO_2-e) at each landfill was deducted from the annual CH_4 generated. The net CH_4 emissions at each landfill are then summed to produce p.a. net CH_4 emissions for New South Wales. Based on the previous method, the overall gas capture rate for all NSW landfills is currently 39% for 2021–22, and is projected to increase to 42% by 2050, with an average projected rate of 41% over the period 2023–2050.

Wastewater emission sources

The assumptions, data and method for projecting wastewater emissions has been substantially updated, with detail provided on the updated method below.

The department engaged ARUP Australia Pty Ltd to develop and apply methods to derive spatially projected wastewater treatment emissions by local government area (LGA) for New South Wales (ARUP 2022). The data inputs, method and results from this work are described in this section.

Emissions were inventoried at LGA resolution for the state for both domestic/ commercial and industrial wastewater treatment. When aggregated, the domestic, commercial and industrial wastewater treatment emissions approximate total NSW STGGI emissions.

The assessment follows the guidelines specified by NGER (Measurement) Determination 2008 (CER 2021), which outlines the equations, formulae and values that must be used or considered for quantifying GHG emissions. This calculation approach is based only on GHG emissions from wastewater treated in:

- domestic and commercial wastewater facilities, such as those operated by utilities like Sydney Water, Hunter Water, and local water utilities
- unsewered domestic wastewater treatment, such as onsite residential septic tank systems
- industrial wastewater facilities across 8 sectors of commodity production in New South Wales.

As domestic and commercial facility catchments span multiple LGA boundaries, the calculation approach requires a spatial disaggregation analysis to allocate emissions to the LGAs that generate the wastewater.

The methodologies for estimating emissions are described later in this section.

Background for domestic/commercial wastewater treatment emissions

The wastewater treatment process is carried out in carefully managed conditions to chemically decompose complex contaminants in the wastewater and produce an effluent that is environmentally suitable for discharge. The decomposition of contaminants generates GHG emissions such as CH_4, CO_2 and nitrous oxide (N_2O).

Additionally, solids in the wastewater are removed from the stream as sludge, and often undergo further treatment steps, such as anaerobic decomposition. This process stabilises the sludge into biosolids for disposal and generates additional volumes of CH_4 as biogas.

Emissions of CO_2 generated are considered to be biogenic and are not included in the inventory. CO_2 produced from the flaring of CH_4 from waste is also considered to be of biogenic origin (DISER 2021b).

Most of the Australian population's domestic and commercial sewage discharge is treated at municipal wastewater treatment plants. According to the *National inventory report 2019* (DISER 2021b), 'approximately 5 per cent of the Australian population is not connected to the domestic sewer and instead utilise onsite treatment of wastewater such as septic tank systems'. These septic tank systems generate CH_4 emissions that are included in the inventory. Since most major treatment facilities span multiple LGAs, domestic and commercial wastewater is in many cases disposed of and treated outside of the LGA boundary, generating area-induced scope 3 emissions for those LGAs.

Most industrial facilities perform some level of wastewater treatment from industrial activities before disposing the effluent into the domestic sewer system to be treated further in municipal facilities.

Some emission sources found in the wastewater treatment process are considered separately under other inventory sectors or considered negligible and not inventoried, including:

- CH_4 emissions from effluent discharge to receiving waters; N_2O emissions from any form of industrial wastewater discharge; N_2O emissions from the discharge of municipal wastewater to ocean and deep ocean receiving waters – consistent with IPCC good practice (IPCC 2006), these emissions are considered negligible and are not reported in the inventory

- CH_4 emissions from the combustion or external transfer of sludge biogas – considered fuel combustion emissions and calculated under a different sector of the GHG inventory (refer to the 'Stationary energy' section)
- CH_4 emissions from the external transfer of sludge – considered solid waste emissions and calculated under a different sector of the GHG inventory (refer to the 'Solid waste disposal' section)
- N_2O emissions from septic tank systems – considered negligible and not reported in the inventory.

The method for calculating emissions from wastewater treatment is based on a model of the pathways for emission generation in the facility and considering the facility's treatment technologies and process streams for wastewater and sludge. This is consistent with IPCC best practice guidelines (IPCC 2006) and NGER guidelines. Cth DCCEEW has developed models to track the decomposition steps of wastewater in NSW wastewater treatment facilities. The model simulates pathways and estimates generated quantities for wastewater emissions based on the volumes of wastewater treated, the discharge environment for the facility, the strength of the contaminants in the wastewater, and the treatment methods utilised by the facility.

The model is driven by multiple data inputs as listed in Table 37 to estimate historical emissions from 2015–16 to 2020–21.

Approximately 74% of the NSW population is collectively serviced across 45 facilities operated by Sydney Water and Hunter Water. These facilities are estimated to constitute 312 kt CO_2-e or 58% of NSW domestic and commercial wastewater treatment emissions (total of 595 kt CO_2-e for 2020–21).

The domestic and commercial wastewater facilities include those operated by the key utilities in New South Wales, with influent volume data (in equivalent population) applied: Sydney Water, Hunter Water, Central Coast Council, Thredbo and Essential Energy. These are referred to as key catchments. Utilities servicing the remainder of New South Wales are referred to as 'local water utilities'.

Additionally, industrial wastewater treatment emissions were estimated across 116 industrial facilities and 8 sectors that meet National Pollutant Inventory (NPI) reporting criteria. The industrial emissions were estimated at 375 kt for 2020–21.

Data sources

Foundational datasets used in the estimation and disaggregation of wastewater treatment emissions are listed in Table 37.

Table 37 Data used in the estimation of wastewater treatment emissions

Data reference	Description	Resolution	Source
DPE 2022g	Population projections	Annual NSW population projections by LGA to 2041 extended to 2050	2020 NSW Common Planning Assumption (Population) Projections
NSW LGA boundaries	NSW LGA spatial data	Administrative boundaries for LGAs	Data.gov.au NSW LGA Geoscape Administrative Boundaries
NSW STGGI 20120–21	NSW wastewater treatment emissions	Total NSW emissions disaggregated by IPCC category and subcategory	STGGI data for category 5D (domestic and commercial, industrial) (NSW GHG 2016–19 dataset as received November 2021)
Cth DCCEEW industrial facility data 2022	Industrial facility identification	Identification (name, location) of facilities by sector in NSW	Cth DCCEEW collated data from facility reporting
NPI data 2016–2020	Industrial facility name, location, employment figures and emissions figures (in addition to facilities identified by DISER)	Reporting results for all industrial facilities identified in the NPI database	NPI database of industrial facilities meeting NPI reporting thresholds
Cth DCCEEW municipal facility data	Municipal facility influent (equivalent population) Municipal facility effluent nitrogen content (tonnes) Municipal facility discharge environment classification	Facility-specific influent and effluent contaminant analytical data up to 2019 for key utilities in NSW Facility-specific discharge environment definition for key utilities in NSW	Cth DCCEEW collated data from utility reporting
Cth DCCEEW commodity production data (2021 to 2022)	Historical national commodity production rates by industry sector	Annual commodity production (in litres or tonnes)	Cth DCCEEW collated data from facility reporting

The following was noted when compiling the data to support emissions estimation:

- The municipal facility influent, effluent and nitrogen dataset was not complete, and estimates were calculated for certain facilities or reporting years. This is not expected to contribute to large errors in the inventory.
- Commodity production is reported on a national sector level, thus, the NSW sector allocations were estimated. This may contribute to errors in estimating the wastewater generated within each sector.
- An economic analysis was applied to forecast the facility-level commodity production rates to estimate industrial wastewater generation. The NPI database only captures facilities meeting a reporting threshold and therefore is not a full representation of all industrial activity in New South Wales.
- Data for certain industrial sectors are confidential and not available for inventory reporting.
- The spatial distribution of LGAs over municipal sewerage catchments was estimated, which may affect emissions distribution by LGA. Furthermore, fluctuations in population density distribution may lead to inaccuracy in spatial disaggregation.
- The emissions pathways in wastewater treatment are dependent on a knowledge of process streams and treatment technologies in place at the facility. There is a significant degree of variation in treatment process combinations used between each industrial facility. Thus, the emissions pathways were formed at a sector level, as there is a higher likelihood of consistency between facilities within each sector.
- There are noted inconsistencies within the STGGI data for the industrial wastewater emissions that indicate a high level of variability in the inventory estimation process.
- Emissions are affected by uncertainties and inaccuracies within the municipal facility data collected by DISER, and by assumptions made in the modelling applied to represent the wastewater treatment pathways. There is also an impact from population density distribution assumptions for the disaggregation step of the NSW population by municipal catchment.
- The lack of data for a number of municipal facilities is an issue. This was mitigated using estimates of the missing data points derived from trends in the remainder of the input data.

Population growth metric

The future population projections for the years 2020–2041 are based on the Australian Statistical Geography Standard 2020 LGA population projections as provided by the department at project inception. These population projections were developed by the department from the NSW Treasury's NSW common planning assumptions as published in March 2022 (DPE 2022g).

The future population projections for the years 2041–42 to 2049–50 were not available. To calculate population growth, the population forecast data supplied by the department (NSW Annual Population Projections, and the Australian Statistical

Geography Standard 2020 LGA population projections) were used. The growth rate was calculated using a compound annual growth rate (CAGR) formula for the period 2016–2040 and applying it annually to 2049–50. The formula applied is:

$$Annual\ population\ growth\ rate = \left[\left(\frac{EV}{BV}\right)^{\left(\frac{1}{NY}\right)} - 1\right] \times 100\%$$

where:

EV = the End Value in the population data supplied by the department, being 2040

BV = the Base Value in the population data supplied by the department, being 2016

NY = the number of years in the forecast period.

Emission estimation method – domestic and commercial wastewater

Chemical oxygen demand (COD) is a common analyte in wastewater treatment. It is a measure of the oxygen equivalent of organic material in wastewater that can be oxidised chemically. In essence, it is used to indicate the quantum of organic material in the wastewater that must be treated. The treatment of this organic material is the source of scope 1 CH_4 emissions in wastewater treatment.

The process flow diagram for CH_4 emissions developed for this assessment is a simplification of a typical wastewater treatment process (Figure 45). It was developed primarily to provide a simple COD balance to quantify COD flows, and in turn, quantify emissions. For this assessment, all COD flows are referred to in terms of mass rates (tonnes p.a.).

The process flow diagram for N_2O emissions developed for this assessment is a simplification of a typical wastewater treatment process (Figure 46). It was developed primarily to provide a simple nitrogen balance to quantify the flows of nitrogen, and in turn, quantify the N_2O emissions. For this assessment, all nitrogen flows are referred to in terms of mass rates (tonnes p.a.).

Emissions from sludge transferred off site are considered solid waste emissions and not part of the scope of this methodology.

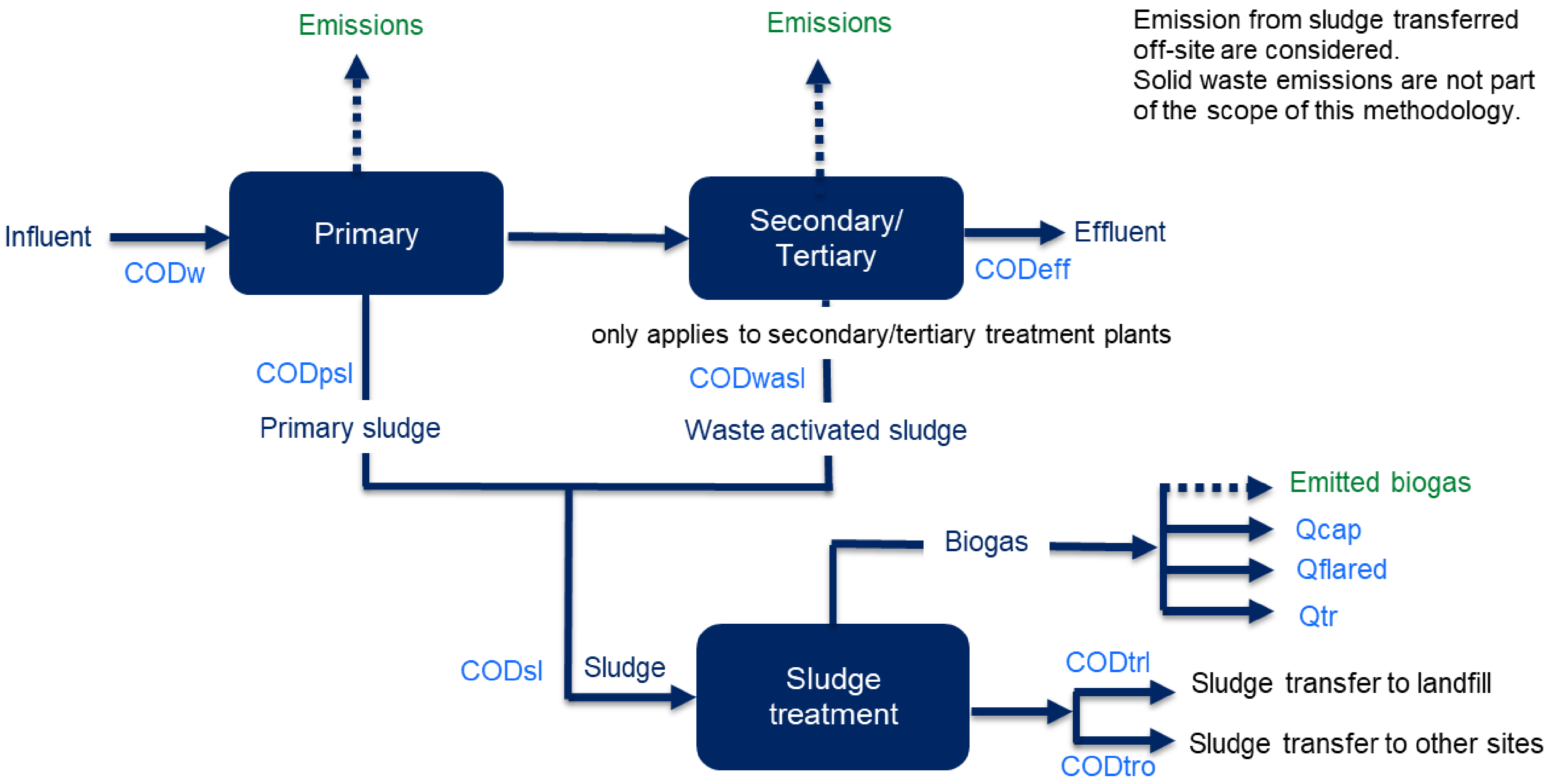

Figure 45 Pathways for methane (CH_4) emissions from domestic and commercial wastewater handling

CODw = COD for wastewater; CODpsl = COD for primary sludge; CODwasl = COD for waste activated sludge; CODtrl = COD for sludge removed to landfill; CODtro = COD for sludge removed to another site; CODsl = COD for combined primary and waste activated sludge; CODeff = COD for effluent stream; Qcap = sludge biogas captured for combustion; Qflared = sludge biogas flared; Qtr = sludge biogas transferred off site

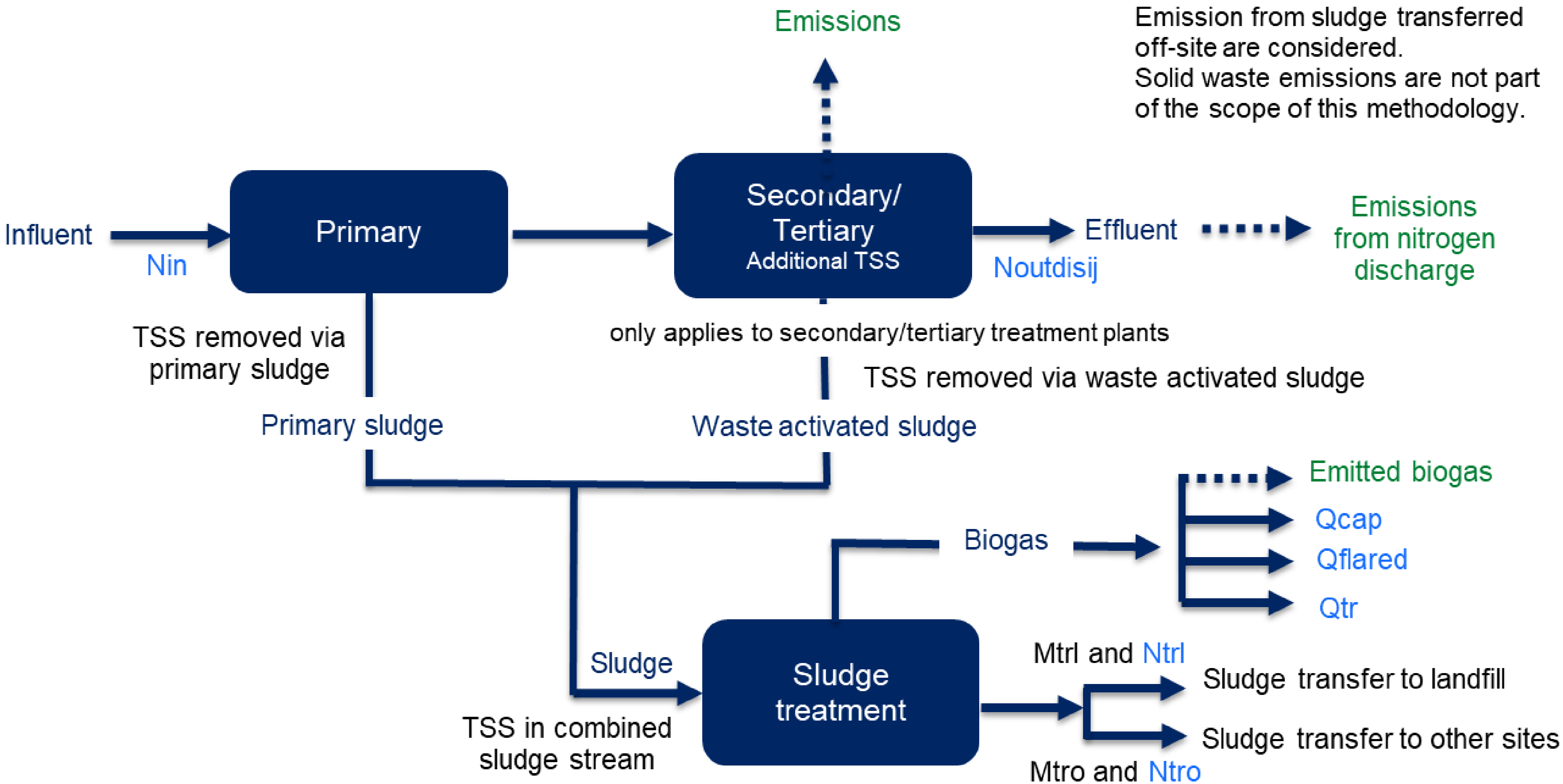

Figure 46 **Pathways for nitrous oxide (N_2O) emissions from domestic and commercial wastewater handling**

TSS = Total suspended solids; Nin = nitrogen quantity in influent; Noutdisij = quantity of nitrogen discharged; Mtrl = dry mass sludge transferred out of plant to landfill; Mtro = dry mass sludge transferred out of plant to a site other than landfill; Ntrl = quantity of nitrogen in sludge transferred out of plant to landfill; Ntro = quantity of nitrogen in sludge transferred out of plant to a site other than landfill

Step 1 – aggregation of population into municipal catchments

The total population serviced by each municipal facility is a critical factor when estimating the volume of wastewater treated and GHG emissions generated from treatment.

Municipal sewerage catchments often span multiple LGAs, especially for large utilities like Sydney Water and Hunter Water. Thus, geospatial analysis was employed to calculate and understand the allocation of LGA populations into municipal catchments.

The remaining population not captured by these catchments was estimated using the Australian Statistical Geography Standard 2020 population projections, allowing for an uplift to capture commercial wastewater generation. This population was modelled as one whole catchment for a treatment process that is representative of the facilities found in these areas. This facility is modelled to service 'residual NSW'. Additionally, the unsewered population of New South Wales was spatially estimated and considered for emissions calculations separately.

This step aggregates the NSW population into municipal facilities for emissions estimation.

Step 2 – estimation of emissions by facility

DISER has gathered influent equivalent population, effluent nitrogen content and discharge environment classification for municipal facilities in New South Wales, capturing a subset of the facilities in the state. The DISER data were collected for each municipal facility modelled for each year, with any missing data points estimated using the rest of the dataset.

For each municipal facility, the emissions pathway was represented in the model to calculate the flows and contaminant decomposition process. Pathways were modelled using process flow parameters to quantify the flows of wastewater being treated, the masses of sludge generated, and the volumes of biogas generated.

The DISER municipal facility data were used as inputs for each facility's process flows. The influent and effluent inputs for the 'residual NSW' facility were estimated using their population aggregates.

The quantities of COD and nitrogen in each flow were used to calculate a balance of COD and nitrogen treated during the process. These losses represent the emissions of CH_4 and N_2O (respectively) released to the atmosphere from each facility.

The process flow parameters for sludge removal modelled the masses of sludge that are externally transferred and removed from the inventory. The model also considered the generation and separation of sludge biogas. Biogas externally transferred or combusted was removed from the calculation to isolate the volume of sludge biogas flared at the facility. Emissions of CH_4 from biogas flaring was estimated for the wastewater treatment sector's GHG inventory.

Additionally, the nitrogen content in the facility effluent was coupled with a classification of the effluent discharge's receiving waters. This allows for an estimate of

N_2O emissions released from waste in the receiving waters. Effluent released into ocean and deep ocean waters is not considered to generate a significant amount of N_2O emissions.

The unsewered population of New South Wales was estimated separately using a model of CH_4 generation per capita. N_2O emissions from septic tank systems are considered negligible and are not included in the inventory.

Step 3 – disaggregation of emissions by LGA

The aggregation method from Step 1 was reversed to reallocate facility emissions to emissions by LGA. This includes unsewered emissions and emissions from the ‘residual NSW’ facility. For domestic and commercial catchments, GIS intersection analysis was done to calculate and spatially divide the allocations between catchments and LGA population. These results allow for a reversible aggregation step to collect population into catchment distribution, estimate facility-level emissions and redistribute the resulting emissions to population by LGA. A summary of the method is given in Table 38.

For populations without identified catchment spatial data, these were collected into a single representative facility and assessed together. The unsewered population was removed from these projections and assessed separately.

There are multiple utility wastewater facilities in New South Wales that service multiple LGAs. Examples of this are the Burwood Beach wastewater treatment works catchment and Sydney Water’s Malabar and North Head systems. Because of this overlap, to enable the emissions calculations per facility, the LGA populations must first be aggregated into each catchment.

Catchment extents were geospatially overlaid with LGA polygons, with catchment area percentage used as each LGA’s portion of the catchment loads. This is considered a suitable method as the most common overlaps occur in residential areas of comparable population densities.

The intersection of catchment and LGA boundaries produces spatial fragments. For each fragment, 2 surface area percentages were calculated as: 1) percentage of LGA, and 2) percentage of catchment. These calculations link the LGA population to the catchment serviced population.

Table 38 Methodology summary – spatial aggregation of LGA population

Component	Details
Inputs	LGA shapefile Catchment shapefiles Population table
Calculations	GIS (intersection) analysis GIS (area calculation) analysis
Assumptions	Comparable population density across catchment All population spatially within a key catchment is considered sewered Sydney Water's Duffys Forest catchment has been merged with the Warriewood catchment as they are operationally linked Catchment percentages were assumed for fragments within Hunter Water, Thredbo and Essential Water catchments Thredbo catchment is approximately 1,000,000 m^2 and services 25% of the sewered population in the Snowy Monaro Regional LGA Essential Water catchment consists of 100% of the Broken Hill LGA 3% of the NSW population is considered unsewered
Outputs	Results of area percentages by catchment and by LGA for each fragment to enable aggregation/disaggregation calculations

Step 4 – inventory projection and scope 1 separation

Once the emissions inventory has been disaggregated by LGA, the department's projections (DPE 2022g) were used to project the inventory into future years using the population growth metric discussed earlier.

Background for industrial wastewater treatment emissions

The NGER (measurement) determination 2008 (CER 2021) methods for industrial wastewater rely on annual commodity production (in tonnes) per sector, as opposed to equivalent population serviced for the domestic/commercial sector.

This information is largely unavailable at a facility level and is not captured in the NPI database. There are only a small number of facilities in the Cth DCCEEW data that have allocated commodity production figures.

The key input is, thus, the commodity production figures provided by Cth DCCEEW at a national level.

The commodity production figures for 2016–2021 were updated using Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) data at a national level. Not all figures were provided on a tonnes p.a. basis. The inputs and the data transformations required are outlined in Table 39.

Table 39 Data transformations for historical national commodity production

Sector	Data transformation
Beer	Input figures adapted from department-provided annual production figures (in L) using assumed conversion of 1.015 kg/L
Dairy	Input figures adapted from department-provided annual production figures (in L) using assumed conversion of 1.0305 kg/L
Fruit and vegetable	Figures provided separately as fruit and as vegetable sectors; sum of figures provided as tonnes p.a. used as inputs
Meat	Figures provided as tonnes p.a. and used as-is for model input
Organic chemicals	Figures provided as tonnes p.a. and used as-is for model input
Paper	Figures provided as tonnes p.a. and used as-is for model input
Sugar	Figures provided as tonnes p.a. and used as-is for model input

The NSW-based commodity production figures per sector were calculated by applying a NSW share of employment for each sector as a percentage-based factor. The adopted value for each sector is 28%, except for organic chemicals, where 32% was adopted.

The historical facility-level employment numbers are available from the NPI database. These are used as an indirect measure of each facility's production rate. This method inherently assumes that there are no gained efficiencies in employment vs production rate (i.e. direct correlation assumed).

The employment numbers were assumed for certain facilities, such as those not captured in the NPI database, based on investigations on each facility or by adopting historical numbers where available in the NPI database before 2016.

Emission estimation method – industrial wastewater

The industrial sectors assessed are listed in

Table 40. These sectors are consistent with sectors outlined in the *National greenhouse and energy reporting (measurement) determination 2008* (CER 2021). Sectors with 2-, 3- or 4-digit Australian and New Zealand Standard Industrial Classification (ANZSIC) codes comprise subsectors that are considered for the assessment.

Table 40 Industrial sectors for assessment with Australian and New Zealand Standard Industrial Classification (ANZSIC) code

Sector	ANZSIC code
Dairy	113
Paper	1510
Meat and poultry	1111 and 1112
Organic chemicals	18 and 19
Sugar	1181
Beer	1212
Wine	1214
Fruit and vegetable	1140

Step 1 – estimation of wastewater volumes generated at each facility

The industrial facilities assessed were identified from industrial facility data collected by Cth DCCEEW and from facilities obtained from the NPI database.

Unlike municipal catchments, industrial wastewater treatment facilities are located onsite at the facility as a point source, therefore, no spatial aggregation step is required aside from identifying the LGA that each facility is located in.

The wastewater volumes in the facility influent are estimated using projections of the facility's commodity production. This data was not available. An economic analysis was employed to estimate the commodity production for each facility based on the employment numbers, which are available from the NPI database. Any missing employment data points were estimated using trends in the remainder of the dataset. The method is described below.

Step 2 – estimation of emissions by facility

Estimation of industrial wastewater emissions is similar to the method used for the domestic and commercial municipal facilities. Instead of equivalent population influents, the wastewater influent volumes are based on the commodity production estimates derived in the previous step.

Since there are a large number of facilities covered in the model, the facilities were considered together based on their sectors (beer, meat, dairy, etc.). It was assumed that the wastewater treatment process within each sector is consistent between each facility. The process parameters for the industrial treatment pathways (sludge removal, biogas production, etc.) were modelled on a sector level.

Consistent with IPCC good practice, N_2O emissions are considered negligible and are not reported in the inventory (IPCC 2006). CH_4 emissions from the combustion or external transfer of sludge biogas and from the external transfer of sludge are removed from the inventory in the same manner as with municipal facilities.

Step 3 – disaggregation of emissions by LGA

The sector-wide emissions were allocated to each facility using their fraction of commodity production within the sector. Subsequently, emissions were disaggregated by LGA using the industrial facility's location.

Since the industrial facilities are point sources of emissions, with wastewater treated onsite, all emissions from industrial wastewater treatment are considered scope 1 within each LGA.

Step 4 – inventory projection

The commodity production estimates were used to project the GHG emissions into future years.

Commodity forecasting approach

Commodity production data is largely unavailable at a facility level. To enable both future projection and spatial disaggregation of the industrial emissions, an economic analysis was undertaken to project the commodity production values at a facility level using data that is publicly available.

The commodity forecasting approach is summarised in Table 41.

Table 41 Methodology summary – economic forecasting of sector growth and commodity production

Component	Details
Inputs	Gross value added (GVA) for agricultural industrial activities ABS general population of Australia 2011–2016 employment figures for the 116 identified facilities
Calculations	GVA per person GVA per sector CAGR of sector activity
Summary	Agricultural GVA represents industrial activity for the 8 assessed sectors National GVA represents NSW GVA National GVA represents sector-specific GVA Employment growth directly represents facility commodity production
Outputs	Sector growth rate for projecting employment growth and hence commodity production

The limitations of this methodology are:

- by linking employment growth directly to commodity production, it does not account for efficiencies gained in industrial employment (i.e. in the event that fewer employees are required to maintain commodity production in the future)
- GVA figures were generated for the overall agriculture industry, which does not account for sector-specific economic dynamics

- GVA figures were averaged across the Australian general population, which does not account for sector-specific or state-specific value generation per employee.

Without commodity production rates disaggregated by facility, this approach was determined, through consultation with the department and technical experts, to be a suitable high-level estimation method based on the data available. Estimating commodity production rates for each of the 116 identified facilities, and based on their individual production activities, would be timeline-prohibitive and thus an approach that is unlikely to achieve a significantly greater level of accuracy.

It is also important to note that industrial activity changes rapidly, with shifts in economic investment and output constantly occurring. No facility is expected to behave similarly in 2050 as it does now. Beyond 2030, any projections will be of lower confidence because of the uncertain nature of long-term projections.

Economic forecasting outputs

The key output of the economic forecasting is the CAGR of employment figures for each sector. The results of the economic analysis are presented in Table 42, which are incorporated into the model as factors.

Table 42 Compound annual growth rate (CAGR) results for each industrial sector

Sector	CAGR of sector
Dairy	−4.01%
Paper	7.41%
Meat	0.00%
Organic chemicals	−0.93%
Sugar	−4.40%
Beer	4.58%
Wine	−2.09%
Fruit and vegetable	−9.43%

The growth rates from Table 42 are applied to each facility, thus providing a forecast of employment numbers annually from 2020–2050.

Data limitations and quality

Emissions are affected by uncertainties and inaccuracies within the industrial facility data collected by Cth DCCEEW, and by assumptions made in the modelling applied to represent the wastewater treatment pathways. There are also further potential impacts from the commodity production estimation step, as it did not consider future efficiencies in industrial production. While employment numbers are not the ideal method for projecting commodity production, the method was necessary due to the lack of granular production data by facility and so that the results can be disaggregated by facility (and hence by LGA).

The Cth DCCEEW and NPI data only capture industrial facilities of note, and in the NPI database's case, industrial facilities meeting certain emissions threshold criteria. As a consequence, there are likely numerous industrial facilities not captured in the inventory, with no data available to robustly account for emissions estimation. These facilities are likely small in scale and do not contribute significantly to the industrial wastewater treatment sector emissions.

Wastewater handling (overall) is estimated to make up approximately 22% of the waste sector's overall emissions, which itself makes up approximately 2% of total NSW emissions; thus, the overall impact of the limitations in data is mitigated by the smaller scale of the state's wastewater treatment emissions.

Other waste sources

As a first approximation, biological treatment and incineration emissions were projected to 2030 based on national emissions projections for these sectors multiplied by the ratio of NSW emissions to national emissions for each sector for the latest Greenhouse Gas Inventory year (2021), with the 2022–2030 trend continued to 2050 (Cth DCCEEW 2023d).

Current policy assumptions

A target of net zero emissions from organic waste by 2030 has been set under the *Net Zero Plan* (DPIE 2020). To achieve this target, a key measure is to reduce the quantity of organic waste being landfilled. The recent *Waste and Sustainable Materials Strategy 2041: Stage 1 2021–2027* (DPIE 2022b) targets reducing the quantity of food organics and garden organics being sent to landfill. The specific targets are:

- 10% reduction in waste generated per person by 2030
- 50% reduction in organics disposed to landfill by 2030.

Efforts to achieve these targets are coordinated by the EPA's Organics Team, with several councils having implemented the waste diversion rollouts to date. It is anticipated that most councils would have implemented waste diversion measures by around 2025–26 and that reduced organic waste tonnes should be recorded by landfill facilities as the waste reduction measures are implemented.

The strategy also states that the NSW Government will:

- require landfill gas capture for landfills over a certain size and all expanded or new landfills with exemptions for certain circumstances
- require net zero emissions for landfills that are subject to an environment protection licence, by a prescribed timeframe.

To complement these regulatory measures, the NSW Government will invest $7.5 million to support the installation of landfill gas capture infrastructure and will explore the introduction of a waste levy rebate for landfills that have landfill gas capture infrastructure installed (DPIE 2022b).

To achieve net zero emissions, offsets may also be required where the above measures fall short of the net zero target.

Preliminary abatement modelling was undertaken for the 2022 projections addressing the specific targets noted above, however, information on set targets related to further landfill gas capture and information on future net zero requirements for landfills was not available at the time the projections were being done.

The following assumptions were thus applied in the preliminary abatement modelling:

- The target was assumed to be a 50% reduction specifically in food organics and garden organics sent to landfill, with other organics such as nappies, sludge and textiles, etc. not reduced. The measures were assumed to commence in 2023 and the target achieved in 2030.
- A 10% reduction in waste generated per person was assumed and taken to be indicative of a 10% reduction in all waste types to be disposed of in NSW landfills.
- The current rate of landfill gas capture varies between an actual 39% in 2022 to a projected 42% in 2050, with an average of 41% over that period. Through consultation with industry stakeholders, MRA Consulting (2020) proposed that landfill gas capture rates can exceed 75% in modern, well-run facilities. Thus, as a possible scenario for the 2023 projections, an overall increase of the landfill gas capture rate to 75% by 2035 (MRA Consulting 2020) was included, beyond which the gas capture rate remains relatively steady to 2050. Individual landfill gas capture rates were adjusted based on: historic gas capture volumes, available information on current gas capture capacity, and recent actual gas capture volumes.

Considerations for projection updates

Future projection updates will consider:

- latest NGERS, waste disposal and population projection data
- measures to increase data sources for council landfills and small landfills, including improving information on waste streams and management practices
- the full impact of the NSW Waste and Sustainable Materials Strategy on waste sector emissions as landfill gas capture targets are finalised.

Projection uncertainty

Emissions projections are inherently uncertain, involving incomplete data, expert judgement and assumptions about future trends in global and domestic economies, policies and technologies. A qualitative assessment was undertaken of uncertainties in the emissions projections for each sector, accounting for the availability and quality of activity data and emission factors or carbon intensities applied (Table 43).

Table 43 Criteria for assessing the level of confidence in the NSW emissions projections

Projection inputs	High confidence	Medium confidence	Low confidence
Activity projection quality	Modelled activity projections using robust assumptions	Modelled activity projections using reasonable assumptions	Assumed trends in activity rates; and/or High-modelled uncertainties in activity rates; and/or Uncertain activity rates
Emission factors/ carbon intensities	Specific emission factors/carbon intensities, with projected changes based on robust assumptions	General emission factors/carbon intensities, with projected changes based on reasonable assumptions	Default emission factors/ carbon intensities

A description of the level of confidence in the emissions projections based on a qualitative assessment of uncertainties is given in Table 44.

Table 44 Level of confidence in business as usual (BAU) NSW emissions projections

Sector/subsector	Projections to 2035	Projections 2035–2050
Electricity generation	Medium	Medium
Stationary energy (excluding electricity)	Medium	Low
Road transport	Medium	Medium to Low
Rail, aviation and water transport	Medium	Low
Fugitives – operational coal mines	High	Medium
Fugitives – other mining	Medium	Low
Industrial processes and product use	Medium	Low
Agriculture	Medium	Low
Land use, land-use change and forestry	Medium	Low
Waste	Medium to High	Medium

The overall level of confidence in emissions projections is considered ‘medium’ for projections to 2035 and ‘low’ for projections over 2035–2050. Despite detailed modelling and reasonable assumptions being generally applied, lower levels of confidence are assigned to some sectors due to uncertainties in the BAU scenario related to the pace of the global energy transition.

Current policy projections include only measures associated with medium to high levels of confidence in the nearer term, with the sector focus and effectiveness of abatement under future stages of the Net Zero Plan being less certain.

References

ABARES (Australian Bureau of Agricultural and Resource Economics and Sciences) (2023a) *Agricultural commodities: September quarter 2023*, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.

ABARES (2023b) *Agricultural commodities: March quarter 2023*, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.

ABS (Australian Bureau of Statistics) (2019) *9309.0 – Motor vehicle census, Australia, 31 Jan 2019*, Australian Bureau of Statistics, July 2019.

ABS (2020a) Survey of motor vehicle use, Australia, Australian Bureau of Statistics.

ABS (2020b) 3101.0 National, state and territory population, accessed July 2021, Australian Bureau of Statistics.

ABS (2021) Motor vehicle census, Australia, 31 January 2021, ABS website.

AEMO (Australian Energy Market Operator) (2021) 2021 Gas statement of opportunities, Australian Energy Market Operator.

AEMO (2022a) '2022 Integrated system plan', Australian Energy Market Operator.

AEMO (2022b) '2022 Gas statement of opportunities', Australian Energy Market Operator.

AEMO (2023) '2023 Gas statement of opportunities', Australian Energy Market Operator.

AEMO Services (2023) 2023 Infrastructure investment objectives report December 2023, AEMO Services Limited.

Almeida AK and Hegarty RS (2021) *Managing livestock to reduce methane emissions: Assessment of strategies for abatement of enteric methane* [PDF 2.6MB], report prepared for the NSW Department of Primary Industries.

ARUP (2022) *Spatial and future projections of industrial and domestic wastewater treatment emissions in NSW, methods paper*, Arup Group, March 2022.

ARUP (2024) Peer review of NSW greenhouse gas projections peer review findings and recommendations report March 2024.

ATAG (2021) *Waypoint 2050*, second edition, Air Transport Action Group, September 2021.

Aurizon (2020) *Climate strategy and action plan* [PDF 2.1MB], Aurizon Holdings Ltd.

BITRE (Bureau of Infrastructure and Transport Research Economics) (2019) Australian aggregate freight forecasts – 2019 update, Report 152, Bureau of Infrastructure, Transport and Regional Economics.

BITRE (2021) Trainline, volumes 1–8, Bureau of Infrastructure and Transport Research Economics.

BITRE (2022a) Airport traffic data 1985–86 to 2021–22, Australian Government Department of Infrastructure, Transport, Regional Development and Communities, accessed October 2021.

BITRE (2022b) Maritime statistics, Bureau of Infrastructure and Transport Research Economics.

Blue Environment (2019) 'Emissions projections from the waste sector, 24 October 2019', prepared for the Department of the Environment and Energy (the report is confidential).

BlueScope (2021) *BlueScope climate action report 2021*, BlueScope Steel Ltd.

BlueScope (2022a) Appendix J, Greenhouse gas report for BlueScope Steel's Blast Furnace No. 6 Reline Project environmental impact statement, BlueScope Steel Ltd.

BlueScope (2022b) *Sustainability report 2021/22*, BlueScope Steel Ltd.

BNEF (Bloomberg New Energy Futures) (2021a) Bloomberg new energy outlook 2021, Bloomberg New Energy Futures.

BNEF (2021b) Electric vehicle outlook, Bloomberg New Energy Futures.

BOM (Bureau of Meteorology) (2022) Bureau of Meteorology Australian Hydrological Geospatial Framework, Australian Bureau of Meteorology.

BOM and CSIRO (2022) *State of the climate 2022*, Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation

Boral (2022a) Annual environmental management review 2022, Boral Ltd.

Boral (2022b) *Sustainability report 2022*, Boral Ltd.

Calix (2022) Press release – Calix and Boral to develop carbon abatement project with $30m in Government Funding, May 2022, Calix Ltd.

CCA (Climate Change Authority) (2020) *Review of the Emissions Reduction Fund, October 2020* [PDF 3.4MB], Climate Change Authority.

CER (Clean Energy Regulator) (2020) Safeguard baselines table – Tomago Aluminium Smelter, Australian Government Clean Energy Regulator.

CER (2021) National greenhouse and energy reporting (measurement) determination 2008, amended July 2021.

CER (2023) NGER Solid Waste Calculator 2022–23, Australian Government Clean Energy Regulator.

CER (2024) *Australian carbon credit units*, Clean Energy Regulator website.

COAG Energy Council (2019) *Australia's National Hydrogen Strategy* [PDF 16MB], Australian Government.

Coal Services (2023) NSW coal industry statistics, Coal Services Pty Ltd.

Cth DCCEEW (Commonwealth Department of Climate Change, Energy, the Environment and Water) (2021) Directory of Important Wetlands in Australia (DIWA), Australian Department of Climate Change, Energy, the Environment and Water, Canberra.

Cth DCCEEW (2022a) *Non-road diesel engines – cost benefit analysis: final report*, Department of Climate Change, Energy, the Environment and Water, Canberra.

Cth DCCEEW (2022b) *Australian energy update 2022*, Australian Department of Climate Change, Energy, the Environment and Water website.

Cth DCCEEW (2022c) *National greenhouse accounts 2020*, Australian Government Department of Climate Change, Energy, the Environment and Water website.

Cth DCCEEW (2022d) *State and Territory greenhouse gas inventories: 2020 emissions*, Australian Department of Climate Change, Energy, the Environment and Water website.

Cth DCCEEW (2023a) *Safeguard Mechanism: about the safeguard mechanism and the reforms* [PDF 411KB], Australian Department of Climate Change, Energy, the Environment and Water, Canberra.

Cth DCCEEW (2023b) *Australia's national greenhouse accounts*, Australian Department of Climate Change, Energy, the Environment and Water website, accessed April 2023.

Cth DCCEEW (2023c) *Australia's national greenhouse accounts – emissions by state and territory*, Australian Department of Climate Change, Energy, the Environment and Water website, accessed April 2023.

Cth DCCEEW (2023d) *State and territory greenhouse gas inventories: 2021 emissions*, Australian Department of Climate Change, Energy, the Environment and Water, Canberra.

Cth DCCEEW (2023e) 'National inventory report 2021 Volume 1', Australian Department of Climate Change, Energy, the Environment and Water, Canberra.

Cth DCCEEW (2023f) 'National inventory report 2021 Volume 2, Annexes', Australian Department of Climate Change, Energy, the Environment and Water, Canberra, April 2023.

Cth DCCEEW (2023g) *Australia's emissions projections 2023*, Australian Department of Climate Change, Energy, the Environment and Water, Canberra, November 2023.

Cth DCCEEW (2023h) *Methodology for Australia's emissions projections 2023*, Australian Department of Climate Change, Energy, the Environment and Water, Canberra, November 2023

Cth DCCEEW (2023i) *Australian energy update 2023*, Australian Department of Climate Change, Energy, the Environment and Water, Canberra.

Cth DCCEEW (2023j) 'National greenhouse accounts factors 2023: for individuals and organisations estimating greenhouse gas emissions', Australian Department of Climate Change, Energy, the Environment and Water, Canberra.

DAWE (Department of Agriculture, Water and Environment) (2020) *Cold hard facts 2020* [PDF 1.1MB], Australian Department of Agriculture, Water and Environment.

DAWE (2021) *Australia's HFC phase-down*, Australian Department of Agriculture, Water and Environment website.

Deloitte (2017) *Western Sydney Airport aviation fuel supply corridor options report* [PDF 2.8MB], prepared by Deloitte Financial Advisory Pty Ltd for the Department of Infrastructure, Regional Development and Cities.

Deloitte (2023) Department of Regional NSW, *Sustainable aviation fuel market study*, May 2023.

Department of Infrastructure and Transport (2010) *Joint study on aviation capacity in the Sydney region* [PDF 56MB], Australian Department of Infrastructure and Transport, Canberra ACT.

Department of Regional NSW (2022) *Fugitive methane emissions from coal mines*, NSW Resources website.

DEWHA (Department of the Environment, Water, Heritage and the Arts) (2009) 'Second national in-service emissions study (NISE2)', *Light duty petrol vehicle emissions testing: RTA.07.2828.0309-final report*, Department of the Environment, Water, Heritage and the Arts, March 2009.

DISER (Department of Industry, Science, Energy and Resources) (2020a) *Australia's emissions projections 2020* [PDF 2.9MB], Australian Department of Industry, Science, Energy and Resources.

DISER (2020b) *Methodology for the 2020 projections* [PDF 1.1MB], Australian Government Department of Industry, Science, Energy and Resources.

DISER (2021a) *Australia's emissions projections 2021*, Australian Department of Industry, Science, Energy and Resources.

DISER (2021b) *National inventory report 2019: volume 2* [PDF 15.6MB], Australian Department of Industry, Science, Energy and Resources.

DISER (2022a) 'Australian Petroleum Statistics 2022', Australian Government Department of Industry, Science, Energy and Resources.

DISER (2022b) *National inventory report 2020, volume 1* [PDF 8.9MB], Australian Department of Industry, Science, Energy and Resources.

DISER (2022c) *National inventory report 2020: volume 2* [PDF 19.6MB], Australian Department of Industry, Science, Energy and Resources.

DISER (2022d) *National inventory report 2020: volume 3* [PDF 8.8MB], Australian Department of Industry, Science, Energy and Resources.

DISR (2023a) *Resources and Energy Quarterly: September 2023*, Office of the Chief Economist, Australian Department of Industry, Science and Resources.

DISR (2023b) *Resources and Energy Quarterly: March 2023*, Office of the Chief Economist, Australian Department of Industry, Science and Resources.

DPE (2022b) *NSW Blue Carbon Strategy 2022–2027* [PDF 11.7MB], NSW Department of Planning and Environment, Parramatta.

DPE (2022c) *Land management*, NSW Department of Planning and Environment website.

DPE (2022d) 'NSW Greenhouse gas emissions projections, 2021 methods paper', Department of Planning and Environment, Parramatta.

DPE (2022f) *Major resource recovery infrastructure grant project summaries*, NSW Department of Planning and Environment website.

DPE (2022g) *Population projections*: 2022 NSW population, household and implied dwelling demand projections, NSW Department of Planning and Environment website.

DPE (2023) *NSW Greenhouse gas emissions projections, 2022 Methods Paper*, Department of Planning and Environment, Parramatta.

DPIE (Department of Planning, Industry and Environment) (2019) *Queensland-Hunter gas pipeline,* NSW Department of Planning, Industry and Environment, Parramatta.

DPIE (2020) 'Net Zero Plan Stage 1: 2020–2030', NSW Department of Planning, Industry and Environment, Parramatta.

DPIE (2021a) Supporting businesses to decarbonise, NSW Climate and Energy Action website.

DPIE (2021c) Net Zero Industry and Innovation Program, NSW Department of Planning, Industry and Environment, Parramatta.

DPIE (2021e) NSW Net Zero Buildings Initiative, NSW Department of Planning, Industry and Environment, Parramatta.

DPIE (2021f) *NSW Hydrogen Strategy, making NSW a global hydrogen superpower* [8.9MB], NSW Department of Planning, Industry and Environment, Parramatta.

DPIE (2022a) *Primary industries productivity and abatement program*, DPIE webpage.

DPIE (2022b) *NSW Waste and Sustainable Materials Strategy 2041, Stage 1: 2021–2027*, NSW Department of Planning, Industry and Environment, Parramatta.

EEA (European Environment Agency) (2019) *EMEP/EEA Air pollutant emission inventory guidebook 2019, 1.A.3.b.i passenger Cars, 1.A.3.b.ii light commercial trucks, 1.A.b.iii heavy-duty vehicles including buses, 1.A.3.b.iv motorcycles*, European Environment Agency, October 2019.

EPA (Environment Protection Authority) (2012) *Air emissions inventory for the Greater Metropolitan Region in New South Wales, 2008 calendar year: on-road mobile emissions*, NSW Environment Protection Authority, August 2012.

EPA (2019) *Air emissions inventory for the Greater Metropolitan Region in New South Wales, 2013 calendar year: on-road mobile emissions*, NSW Environment Protection Authority, October 2019.

EPA (2023a) *EPA Climate Change Policy*, NSW Environment Protection Authority, Parramatta.

EPA (2023b) *EPA Climate Change Action Plan 2023–26*, NSW Environment Protection Authority, Parramatta.

EPA (2023c) The Waste and Resource Reporting Portal, NSW Environment Protection Authority.

ERM (2023) *WP2: Industrial decarbonisation pathway modelling final report*, 23rd October 2023

FCAI (Federal Chamber of Automotive Industries) (2023) VFACTS new vehicles sales Jan 2020 to Jun 2023, FCAI, Kingston ACT.

Gavran M (2020) *Australian forest and wood products statistics datasets 2020*, ABARES technical report, Canberra, November 2020, doi:10.25814/8vah-r089

GHD (2023) 2023 Update to PIPAP abatement modelling - technical memorandum and workbook, December 2023.

Gjerek M, Morgan A, Gore-Brown N and Womersley G (2021) *Diesel use in NSW agriculture and opportunities to support net zero emissions* [PDF 1.8MB], Australian Alliance for Energy Productivity for NSW Department of Primary Industries.

Graham PW, Havas L, Brinsmead T and Reedman L (2019) *Projections for small scale embedded energy technologies*, report to AEMO, CSIRO, Australia.

Graham P and Havas L (2021) *Electric vehicle projections 2021*, CSIRO, Australia, May 2021.

IATA (International Air Transport Association) (2021) *Aircraft technology roadmap to 2050* [PDF 2021], International Air Transport Association, July 2021.

IATA (2022) *Air passenger numbers to recover in 2024*, IATA press release, 1 March 2022, International Air Transport Association.

IBISWorld (2022) Expert industry research you can trust, IBISWorld, Melbourne.

ICCT (International Council on Clean Transportation) (2017) *Too low to be true? How to measure fuel consumption and CO2 emissions of plug-in hybrid vehicles, today and in the future,* International Council on Clean Transportation website.

ICCT (2019) *From laboratory to road*, International Council on Clean Transportation website.

IPCC (Intergovernmental Panel on Climate Change) (2000) 'IPCC good practice guidance and uncertainty management in national greenhouse gas inventories', Chapter 5, 5.7, Intergovernmental Panel on Climate Change.

IPCC (2006) *Guidelines for national greenhouse gas inventories, Volume 5 Waste*, Intergovernmental Panel on Climate Change.

IPCC (2009) *2019 Refinement to the 2006 IPCC guidelines for national greenhouse gas inventories*, prepared by the Task Force on National Greenhouse Gas Inventories, IPCC.

IPCC (2021) Sixth assessment report, technical summary, in *Climate Change 2021: The physical science basis, contribution of working group I to the sixth assessment report of* *the Intergovernmental Panel on Climate Change*, Working Group 1, Intergovernmental Panel on Climate Change.

Manildra (2022) Breaking ground on cogeneration transition – Manildra Group, Dec 07, 2022.

MCi (Mineral Carbonation International) (2021) Press release – MCi awarded $14.6 million Federal Government grant, Mineral Carbonation International.

McKinsey (2021) analysis as referenced in the Australia's long-term emissions reduction plan: modelling and analysis as published by the Australian Government in June 2022.

MRA Consulting (2020) 'NSW landfills emissions', unpublished report compiled on behalf of the NSW Environment Protection Authority, October 2020.

Myhre G, Shindell D, Bréon F-M, Collins W, Fuglestvedt J, Huang J, Koch D, Lamarque J-F, Lee D, Mendoza B, Nakajima T, Robock A, Stephens G, Takemura T and Zhang H (2013) 'Anthropogenic and Natural Radiative Forcing' [PDF 18.5MB], in: *Climate Change 2013: The physical science basis. contribution of working group I to the fifth assessment report of the Intergovernmental Panel on Climate Change*, Stocker TF, Qin D, Plattner G- K, Tignor M, Allen SK, Boschung J, Nauels A, Xia Y, Bex V and Midgley PM (eds.), Cambridge University Press, Cambridge, UK and New York, USA.

Nishant N, JP Evans, G Di Virgilio, SM Downes, F Ji, KKW Cheung, E Tam, J Miller, K Beyer and ML Riley (2021) 'Introducing NARCliM1.5: evaluating the performance of regional climate projections for southeast Australia for 1950-2100', *Earth's Future*, https://doi.org/10.1029/2020EF001833

NSW Government (2020a) *Electricity Infrastructure Roadmap*, NSW Climate and Energy Action website.

NSW Government (2020b) *Energy Security Safeguard*, NSW Climate and Energy Action website.

NSW Government (2021) *NSW Electric Vehicle Strategy*, NSW Climate and Energy Action website.

NSW Government (2022a) *SEED: The Central Resource for Sharing and Enabling Environmental Data in NSW*, NSW Government website.

NSW Government (2022b) *NSW National Parks and Wildlife Service Carbon positive by 2028* [PDF 6.2MB], NSW Government

NSW Government (2022c) *NSW natural capital statement of intent: recognising the value of nature* [PDF 2MB], NSW Government.

NSW Government (2022d) *About the Peak Demand Reduction Scheme*, NSW Climate and Energy Action website.

NSW Government (2022e) *Sustainable Buildings SEPP*, NSW Government website.

NSW Government (2023) *Energy Savings Scheme*, NSW Climate and Energy Action website.

OCSE (Office of the NSW Chief Scientist and Engineer) (2020) *Opportunities for prosperity in a decarbonised and resilient NSW* [PDF 2.8MB], Decarbonisation Innovation Study, August 2020, NSW Chief Scientist and Engineer.

OCSE (2023) *Refreshed opportunities with a systematic approach for the NSW clean economy*, NSW Decarbonisation Innovation 2023 Study, November 2023, NSW Chief Scientist and Engineer

OECC (Office of Energy and Climate Change) (2023) *NSW Electricity Infrastructure Roadmap benefits modelling report – a method for estimating the consumer benefits of the NSW Electricity Infrastructure Investment Act 2020*, Office of Energy and Climate Change, NSW Treasury.

OECD (Organisation for Economic Co-operation and Development) (2022) *OECD-FAO Agricultural outlook 2022–2031*, accessed 4 October 2023, Organisation for Economic Co-operation and Development.

OEH (Office of Environment and Heritage) (2016) *NSW climate change policy framework*, NSW Office of Environment and Heritage, Sydney.

Orica (2021) *Press release – Orica announces ambition for net zero emissions by 2050*, October 2021, Orica Australia Pty Ltd.

Orica (2022a) *2022 Annual environmental management report*, December 2022, Orica Australia Pty Ltd.

Orica (2022b) *Climate action report 2022*, Orica Australia Pty Ltd.

Orica (2023) *Climate action report 2023*, Orica Australia Pty Ltd.

Pacific National (2021) *ESG Report FY2021* [PDF 4.6MB], Pacific National Holdings Pty Ltd.

Palaris (2021) 'Opportunities of fugitive emissions abatement', Report DPE5704, final draft 1 June 2021, confidential report prepared for the Department of Planning and Environment.

Palaris (2022) 'Preliminary analysis of coal emissions abatement', Report DEP6236-04, final draft 15 July 2022, confidential report prepared for the Department of Regional NSW, Mining Exploration and Geoscience.

PwC (PricewaterhouseCoopers) (n.d.) *Corporate travel: collaboration is essential for successful COVID recovery*, PricewaterhouseCoopers website.

Qantas (2022) *Qantas Group climate action plan* [PDF 14.5MB], Qantas Airways Ltd.

Qenos (2022a) *Our plants*, Qenos website.

Qenos (2022b) *Qenos profile* [PDF 23KB], Qenos.

Qenos (2022c) *Qenos and Santos announce feasibility study for the supply of hydrogen to reduce emissions in New South Wales*, Qenos website.

Reedman LJ, Chew MS, Gordon J, Sue W, Brinsmead TS, Hayward JA and Havas L (2021) *Multi-sector energy modelling* [PDF 3.3MB], CSIRO, Australia, July 2021.

Ridoutt B, Lehnert SA, Denman S, Charmley E, Kinley R and Dominik S (2022) 'Potential GHG emission benefits of *Asparagopsis taxiformis* feed supplement in Australian beef cattle feedlots', *Journal of Cleaner Production*, 337:130499, doi: 10.1016/j.jclepro.2022.130499

Sydney Airport (2019) 'Sydney Airport master plan 2039', Sydney Airport Corporation Ltd.

TER (2021) 'Estimation of total travel and total emissions for the NSW on-road fleet with the Australian Fleet Model (AFM) and COPERT Australia', Transport Emission/Energy Research, unpublished report.

TfNSW (Transport for New South Wales) (2022a) NSW Government Zero Emission Bus Transition Strategy, Transport for New South Wales.

TfNSW (2022b) *Future Transport Strategy: our vision for transport in NSW*, Transport for New South Wales.

TfNSW (2022d) *Opal trips – ferry,* Transport for New South Wales website.

TfNSW (2022e) Train patronage – monthly figures, Transport for New South Wales.

TfNSW (2022f) Travel insights, Transport for New South Wales.

TfNSW (2022g) NSW Steel volume demand forecast – pers. comm. by email from Mende Gorgievski, June 2022.

TfNSW (2023) *Towards net zero emissions - freight policy*, Transport for New South Wales.

TNO (2018) *Real world fuel consumption of passenger cars based on monitoring of Dutch fuel pass data 2017*, TNO, Netherlands.

UN (United Nations) (1992) *United Nations framework convention on climate change* [PDF 80KB], UN.UN (2015) *Paris agreement* [PDF 4.3MB], United Nations.

Waters C., Cowie, A., Wang, B., Simpson, M., Gray, J., Simmons, A and Stephens, S (2020). Abatement opportunities from the agricultural sector in New South Wales: Modelling to support the development of the Primary Industries Productivity and Abatement Program NSW Department of Primary Industries. ISBN: 978-1-76058-415-3

Wood N, Beauman M and Adams P (2021) *An indicative assessment of the four key areas of climate risk for the 2021 NSW Intergenerational report* [PDF 575KB], Treasury Technical Research Paper Series, NSW Treasury, TTRP 21-05, April 2021.

Glossary and shortened forms

Term	Shortened form	Description
Abatement		Reduction of greenhouse gas (GHG) emissions, either their degree or their intensity
Action		A sub-component of a NSW Government program developed to reduce GHG emissions
Activity		A process that generates GHG emissions or uptake. In some sectors it refers to the level of production or manufacture for a given process or category
Actual		With reference to emissions, observed or past GHG emissions as opposed to forecasted or projected
Australia New Zealand Standard Industrial Classification	ANZSIC	A classification system developed by the Australian Bureau of Statistics and Statistics New Zealand to organise information from entities based on their main activity An ANZSIC code is a level of classification in the ANZSIC system
Australian Bureau of Agricultural and Resource Economics and Sciences	ABARES	The research arm of the Australian Government Department of Agriculture, Fisheries and Forestry that provides professionally independent data, research, analysis and advice to inform decisions affecting Australian agriculture, fisheries and forestry
Australian Bureau of Statistics	ABS	Australia's national statistical agency
Australian carbon credit units	ACCU	Financial instruments awarded to eligible energy efficiency, renewable energy generation, and carbon sequestration projects that result in a reduction of GHG emissions. One ACCU represents the avoidance or removal of one tonne of carbon dioxide equivalent GHG.
Australian Energy Market Operator	AEMO	Manages electricity and gas systems and markets across Australia

Term	Shortened form	Description
Australian Energy Statistics	AES	The official source of energy statistics for Australia
Base year		A historical datum against which an entity's emissions are tracked over time (e.g. year)
Battery electric vehicles	BEV	A type of electric vehicle that uses chemical energy stored in rechargeable battery pack.
Business as usual	BAU	Projected emissions that do not take into account NSW Government policies, programs and actions to abate GHG emissions; excludes corporate commitments
Compound annual growth rate	CAGR	The mean annualised growth rate for compounding values over a given time period
Carbon dioxide	CO_2	A naturally occurring gas produced through the burning fossil fuels, biomass, as a result of land-use changes and industrial processes (e.g. cement production). It is the main anthropogenic GHG that affects the Earth's radiative balance and the reference gas against which other GHGs are measured. It has a global warming potential of 1
Category		A property of each reported activity; a broad group associated with the reported activity that is producing emissions, consuming or producing energy
Clean Energy Regulator		An Australian Government body responsible for accelerating carbon abatement for Australia
Climate change policy and action plan	CCPAP	The NSW EPA's climate change policy and action plan
CO_2 equivalent	CO_2-e	The universal unit of measurement to indicate the global warming potential of each GHG, expressed in terms of the global warming potential of one unit of CO_2. It is used to evaluate the climate impact of releasing, or avoiding the release of, different GHGs on a common basis
Chemical oxygen demand	COD	A measure of the amount of oxygen that can be consumed by reactions in a solution
Coal Innovation NSW	CINSW	A NSW Government program to advance low emissions coal technologies research and development.

Term	Shortened form	Description
Coke oven gas	COG	A fuel gas produced during the manufacture of metallurgical coke
Commonwealth Government Department of Climate Change, Energy, the Environment and Water	Cth DCCEEW	An Australian Government department
Commercial & industrial	C&I	Referring to a waste stream produced from commercial and industrial sources
Construction & demolition	C&D	Referring to a waste stream produced from construction and demolition sources
Current policy		Projected emissions that build upon the base case but also take into account NSW Government policies, programs and actions to abate GHG emissions
Department of Industry, Science, Energy and Resources	DISER	An Australian Government department
NSW Government Department of Climate Change, Energy, the Environment and Water	the department	A NSW Government department, previously known as the Department of Planning and Environment
Department of Planning and Environment		A NSW Government department, now known as the Department of Climate Change, Energy, the Environment and Water
Department of Planning, Industry and Environment		A NSW Government department, now known as the Department of Climate Change, Energy, the Environment and Water
Direct reduced iron	DRI	Iron produced from the direct reduction of iron ore by a reducing gas
Electric vehicle	EV	A vehicle that uses one or more electric motors for propulsion, including battery electric vehicles, fuel cell electric vehicles, hybrid and plug in hybrid electric vehicles
Emission		The release of GHGs into the atmosphere
Emission factor		The quantity of GHGs emitted per unit of a specified activity
Emissions intensity	EI	The total emissions divided by either the total energy content of the fuel, the total energy used in a sector or the total production for a sector

Term	Shortened form	Description
Enteric fermentation		A ruminant digestive system process by which plant material is broken down by bacteria in the gut under anaerobic conditions
Environment Protection Authority	EPA	The primary environmental regulator for NSW
Environment protection licence	EPL	Issued by the EPA to the owners or operators of various industrial premises under the Protection of the Environment Operations Act 1997
European Union	EU	A union of 27 member states that are located in Europe
Flaring		The combustion of unwanted or excess gases and/or oil at an oil or gas production site, gas processing plant or oil refinery
Forecast		A prediction or estimate of future events
Fuel type		The specific fuel or energy commodity
Full Carbon Accounting Model	FullCAM	FullCAM is a modelling framework comprised of integrated sub-models for estimating impact to carbon stocks and emissions under varying land use, land-use change and forestry management practices and temporal conditions
Gas statement of opportunities	GSOO	AEMO's forecast of annual gas consumption and maximum gas demand
Global warming potential		The relative warming effect of a unit mass of a gas compared with the same mass of CO_2 over a specific period
Greenhouse gas	GHG	Atmospheric gases responsible for causing changes to global climate. The major GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_20). Less prevalent but very powerful GHGs are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6)
Gross state product		A measure of the value of all goods and services produced within a state
Gross value added	GVA	An economic metric that measures the contribution of a entitty to an economy

Term	Shortened form	Description
Hydrofluorocarbons	HFCs	Often used as refrigerants, HFCs are a GHG used as substitutes for chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs)
Industrial processes and product use	IPPU	A GHG inventory sector that includes emissions from a range of industrial sources; includes GHGs from chemical reactions (other than combustion that is generally for energy purposes), and from the use of synthetic gases such as halocarbons
Intergovernmental Panel on Climate Change	IPCC	The international body responsible for assessing the state of knowledge about climate change to increase international awareness of climate change science and provide guidance to the international community on issues related to climate change
Kilotonne	kt	One thousand tonnes
Land use, land-use change and forestry	LULUCF	A GHG inventory sector that covers emissions and removals of GHGs resulting from direct human-induced land use, land-use change and forestry activities
Local government area	LGA	An administrative division that a local government is responsible for
Long-term		In the context of emissions projections within this report, the period from 2030–2050
Market impact		The change in the price of a commodity or asset caused by the trading of that commodity/asset
Matters to be identified		Matters to be identified by entities and/or by particular sources of emissions specified under regulations 4.10, 4.11, 4.13, 4.14, 4.15, and 4.17 of the National Greenhouse and Energy Reporting Regulations 2008
Methane	CH_4	One of the GHGs to be mitigated under the Kyoto Protocol and a major component of natural gas and associated with hydrocarbon fuels
Metropolitan		A region with a densely populated urban centre surrounded by less populated areas

Term	Shortened form	Description
Mining, Exploration and Geoscience	MEG	A NSW Government group now referred to as NSW Resources within the Department of Primary Industries and Regional Development
Modelling		Using abstract or mathematical models to assist with calculations and predictions
Municipal solid waste	MSW	A waste stream from collected from households and councils
Narrabri Gas Project	NGP	A coal seam gas project operated by Santos
National Greenhouse Accounts		National GHG inventories submitted by the Australian Government to meet its reporting commitments under the United Nations Framework Convention on Climate Change (UNFCCC; UN 1992) and the 1997 Kyoto Protocol to that Convention
National Greenhouse and Energy Reporting Scheme	NGERS	The National Greenhouse and Energy Reporting Scheme is a single national framework for reporting company information about: • greenhouse gas emissions • energy production • energy consumption.
National Pollutant Inventory	NPI	A pollution tracking and reporting system for industrial facilities
Navigation		All civilian (non-military) marine transport of passengers and freight. Domestic marine transport consists of coastal shipping (freight and cruises), interstate and urban ferry services and small pleasure craft movements
Near-term / Near term		In the context of emissions projections within this report, the period from 2021–2030
Net Zero Industry Innovation Program	NZIIP	A NSW Government program designed to support GHG emission reductions across industry
Nitrous oxide	N_2O	One of the GHGs to be mitigated under the Kyoto Protocol, mainly from agricultural practices (soil and animal manure management), but also from sewage treatment, fossil fuel combustion and chemical industrial processes. NO_2 is also produced naturally from a wide variety of biological sources in soil and water

Term	Shortened form	Description
NSW Climate Change Fund		The NSW Climate Change Fund is critical to achieving the government's 2050 net zero emissions target. The fund was established under Part 6A of the *Energy and Utilities Administration Act 1987*.
NSW Net Zero Emissions Dashboard		The NSW Net Zero Emissions Dashboard presents past and projected future greenhouse gas emissions for New South Wales.
Office of the Chief Economist	OCE	An Australian Government department
Organisation for Economic Co-operation and Development	OECD	An international organisation that develops international standards and solutions to social, economic and environmental challenges.
Ozone-depleting substance		A compound that contributes to stratospheric ozone depletion; includes CFCs, HCFCs, halons, methyl bromide, carbon tetrachloride and methyl chloroform. These compounds are very stable in the troposphere and only degrade under intense ultraviolet light in the stratosphere. Upon breaking down they release chlorine or bromine atoms, which depletes ozone
Perfluorocarbons	PFC	Organofluorine compounds containing carbon and fluorine
Petajoule	PJ	A unit of energy equivalent to 10^{15} joules
Port Kembla Gas Terminal	PKGT	A LNG import terminal project at Port Kembla NSW
Primary Industries Productivity and Abatement Program	PIPAP	A NSW government program designed to support GHG emission reductions across the agriculture and land sectors
Program		A framework to manage strategic goals and associated funding to achieve the NSW Government's emissions reduction targets under the Net Zero Plan and focused on specific GHG inventory sectors
Projection		The potential future evolution of a quantity or set of quantities computed with the aid of a model. Projections are based on assumptions concerning, for example, future socioeconomic and technological developments that may or may not occur

Term	Shortened form	Description
Reporting		The presentation of data to internal and external users that include regulators, the general public or specific stakeholder groups
Resources and Energy Quarterly	REQ	A publication produced by the Department of Industry Science and Resources
Run-of-mine	ROM	Refers to the volume of raw coal extracted from a mine
Scenario		A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about relationships and the key driving forces. Scenarios are neither predictions nor forecasts; they are used to provide a perspective on the implications of developments and actions
Scope		Used to structure direct and indirect GHG emissions from activities, based on where they occur relative to the activity
Scope 1 emissions		GHG emissions into the atmosphere as a direct result of an activity, or series of activities
Scope 2 emissions		GHG emissions occurring as a consequence of the indirect consumption of an energy commodity, such as the use of grid-supplied electricity, heat, steam and/or cooling within the relevant boundary
Scope 3 emissions		Indirect GHG emissions other than scope 2 that are generated in the wider economy
Sector		Similar to the UNFCCC classification of sectors, sectors for emissions reporting under the Net Zero Plan include 'Electricity generation', 'Stationary energy' (excluding electricity generation), 'Transport', 'Fugitives', 'Industrial processes and product use' (IPPU), 'Agriculture', 'Land use, land-use change and forestry' (LULUCF) and 'Waste'
Solvent		An organic liquid used for cleaning or to dissolve materials
Source		Any process or activity that releases a GHG, aerosol or a precursor of a GHG into the atmosphere

Term	Shortened form	Description
State and Territory Greenhouse Gas Inventory	STGGI	An inventory of GHG emissions for Australian states and territories
Stationary energy		Sector that includes the combustion of fuels within an apparatus in a fixed location that is designed to raise heat and use it as such, or as mechanical work
Subcategory		A subdivision of a subsector
Subsector		A subdivision of a sector
Sustainable aviation fuel	SAF	An aviation fuel derived from a variety of feedstocks
Terajoule	TJ	A unit of energy equivalent to 10^{12} joules
Transport for New South	TfNSW	A NSW Government agency
United Nations Framework Convention on Climate Change	UNFCCC	The entity that established an international environmental treaty in 1994 to combat human interference with the climate system. Parties to the convention have agreed to work towards achieving the ultimate aim of stabilising 'greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'
Ventilation air methane	VAM	Low concentration methane in underground mines extracted through a ventilation shaft
Vehicle kilometres travelled	VKT	Aggregate sum of the kilometres travelled by all vehicles within the relevant domain, which may be across all vehicles in the state, or for only specific vehicle types and/or regions
Venting		The release of gas into the atmosphere without combustion, either at the production site, refinery or stripping plants, to dispose of non-commercial gas or to relieve system pressure
Waste and Resource Reporting Portal	WARRP	NSW EPA portal to report waste contributions