NSW greenhouse gas emissions projections 2024

Methods paper

Department of Climate Change,
Energy, the Environment and Water

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This resource may contain images or names of deceased persons in photographs or historical content.

Artist and designer Nikita Ridgeway from Aboriginal design agency Boss Lady Creative Designs created the People and Community symbol.

Cover photo: Wind turbine at Hampton Wind Farm renewable energy source. Simone Cottrell /DCCEEW

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Environment and Heritage Group
Department of Climate Change,
Energy, the Environment and Water
Locked Bag 5022, Parramatta NSW 2124
Phone: +61 2 9995 5000 (switchboard)
Phone: 1300 361 967 (Environment and Heritage enquiries)
TTY users: phone 133 677, then ask for 1300 361 967
Speak and listen users: phone 1300 555 727, then ask for 1300 361 967
Email info@environment.nsw.gov.au
Website www.environment.nsw.gov.au

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Contents

List of tables

List of figures

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 aims to:

- summarise the emissions trends in each sector
- detail 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 a current policy scenario. The BAU scenario shows the GHG emissions trajectory which accounts for major factors impacting NSW emissions, including population and market trends and current levels of GHG abatement technology adopted across the economy. The BAU scenario 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 scenario is developed based on the BAU scenario, but accounts for emissions reductions projected to be achieved by the Net Zero Plan and related policies. The current policy scenario shows how the state is tracking towards the legislated NSW emissions reduction targets, based on current policy settings.

In other words, the current policy projections are effectively BAU plus the abatement achieved under the Net Zero Plan and related policies.

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 future stages of the Net Zero Plan over 2030 to 2050.

The gap between the emissions trajectories and emission reduction targets informs the level of effort required.

The BAU and 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.

Under the current policy scenario, more work is needed to meet our emission reduction targets, with New South Wales projected to be 46% below 2005 levels by 2030 and 62% 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 emission reduction targets, policies and programs
- monitoring and reporting on progress towards meeting NSW's emission reduction 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 the 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 (that is, emissions into the atmosphere as a direct result of an activity) have been developed for a business-as-usual (BAU) scenario and a current policy scenario, 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 future stages of the Net Zero Plan over 2030 to 2050.

The **current policy scenario** shows how the state is currently tracking towards the legislated NSW GHG emissions reductions targets based on current policy settings.

The gap between the emissions trajectories and emissions reduction targets informs the level of effort required.

Emissions projection results

The business-as-usual (BAU) and current policy emissions projections for New South Wales are presented and discussed in this section. A more detailed description of the emissions trends, as well as assumptions and methods, for specific sectors is provided in subsequent sections.

Tracking to emission reduction targets

NSW emissions were inventoried to be 110 million tonnes carbon dioxide equivalent (Mt CO_2-e) in 2022, representing 26% of Australia's total emissions and a 27% reduction on 2005 levels (Cth DCCEEW 2024 a, b). NSW emissions have generally declined since peaking in 2006, except for a period between 2017 and 2018 where NSW emissions temporarily increased. This coincides with a period when emissions from the electricity sector increased and large fluctuations in land sector sequestration were modelled.

The latest BAU and current policy projections are shown in Figure 1. The projections show that under current policy settings, New South Wales is not on track to achieve its emissions reduction targets, achieving 46% below 2005 levels by 2030 and 62% below 2005 levels by 2035. In 2030, the abatement gap to reaching the target is 7.2 Mt CO_2-e, while in 2035 the abatement gap to hitting our target is 12.6 Mt CO_2-e. In 2050, there are 18.0 Mt CO_2-e of residual emissions projected. The emission reduction assumptions for each sector are described in each sectoral chapter.

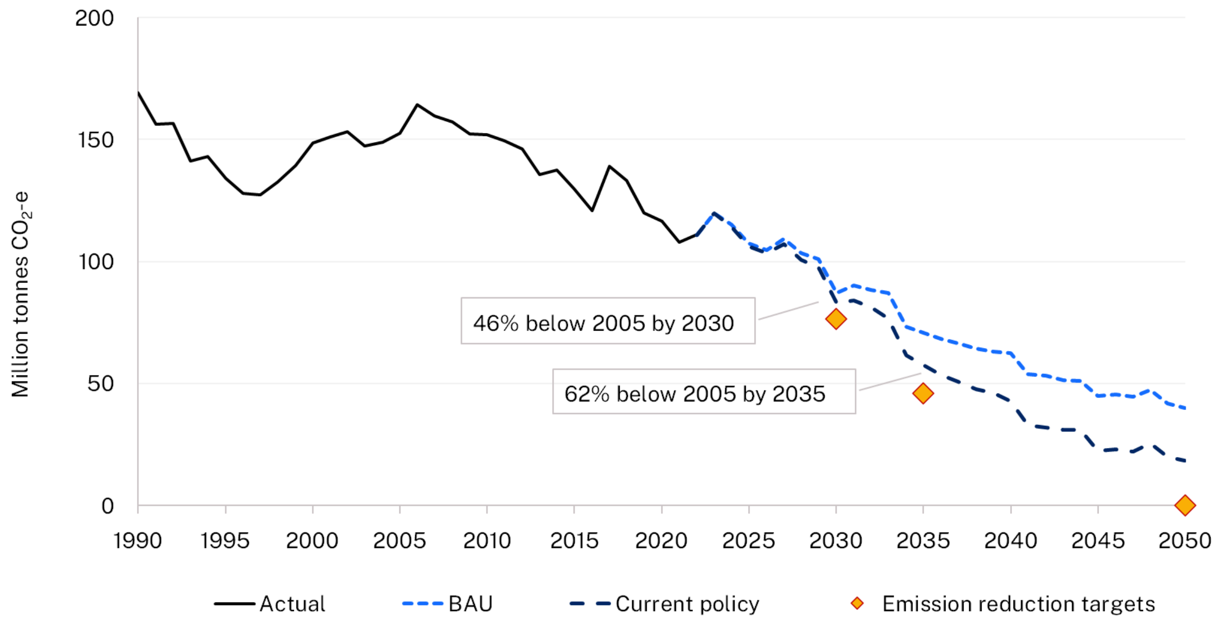

Figure 1 **NSW greenhouse emissions as inventoried (1990–2022) and projected BAU and current policy scenario (2023–2050)**

NSW's BAU and current policy projections are summarised in Table 1. It is noted that a separate BAU emissions scenario for the electricity sector is not modelled for this update, therefore the BAU trajectory includes emission reductions due to the *Electricity Infrastructure Roadmap* (NSW Government 2020a) modelling. Therefore, the reductions from 2005 for the BAU and current policy scenarios are closer than in previous projections updates, particularly in 2030.

Table 1 **NSW emissions as inventoried (2005, 2022) and projected (2030, 2035, 2050) compared to NSW emissions reduction targets**

	NSW Greenhouse Inventory		Projected NSW emissions		
	2005	2022	2030	2035	2050
BAU (Mt CO_2-e) Reduction below 2005	152.7	110.0 –27%	87.1 –43%	70.7 –54%	40.0 –74%
Current policy (Mt CO_2-e) Reduction below 2005	–	–	83.0 –46%	57.4 –62%	18.2 –88%
NSW emissions reduction targets	–	–	76.4 50% below 2005 levels	45.8 70% below 2005 levels	Net zero emissions

Summary of the emission trends

Inventoried emissions and current policy emissions projections by sector are shown in Figure 2 and summarised in Table 2.

Table 2 **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	2022	2030	2035	2050
Electricity generation	58.1	43.3	19.9	8.4	1.1
Stationary energy	17.4	16.6	13.1	10.4	6.5
Transport	23.9	23.5	24.0	19.5	6.7
Fugitive emissions	19.8	10.6	13.2	7.6	1.8
Agriculture	21.6	20.2	16.5	15.6	13.4
Industrial processes and product use	13.9	13.1	10.9	10.0	3.8
Waste	5.5	4.3	3.7	2.8	3.3
Land use, land-use change and forestry	-7.6	-20.6	-18.3	-17.1	-18.4

Sector	NSW Greenhouse Inventory ($Mt\ CO_2$-e)		Current policy projections ($Mt\ CO_2$-e)		
	2005	2022	2030	2035	2050
Total emissions	152.7	111.0	83.0	57.4	18.2

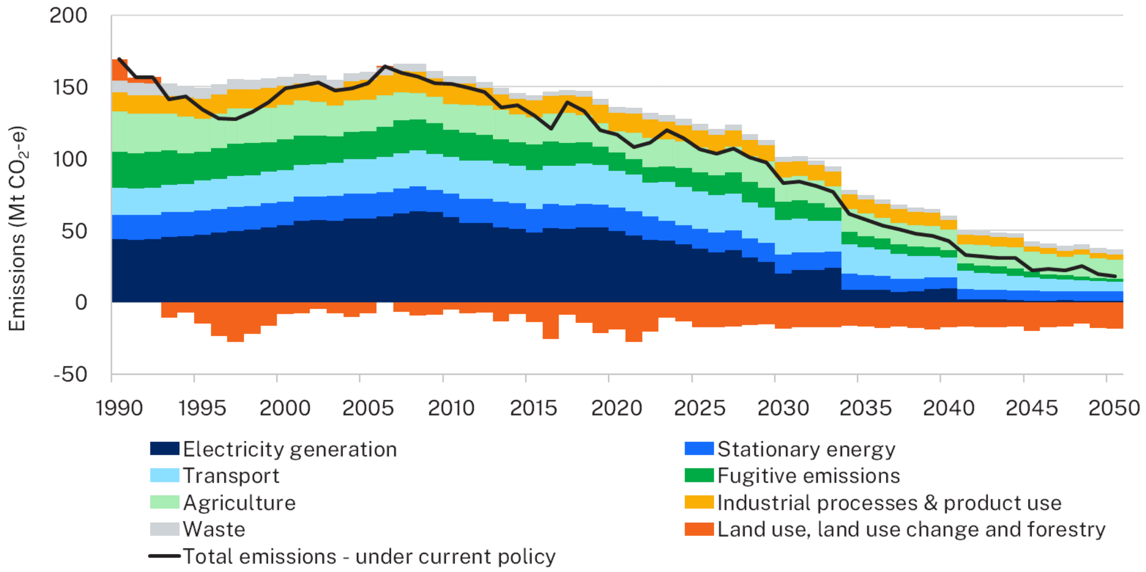

Figure 2 **NSW emissions by sector showing inventory estimates (1990 to 2022) and emissions projections under the current policy scenario (2023 to 2050)**

Projected reductions in NSW emissions by sector over 2023 to 2035, including reductions under the BAU and current policy as tracking are shown in Figure 3. As described above, the reduction in emissions from electricity generation is accounted for in the BAU trajectory, due to a single modelling scenario for the 2024 update.

Emission reductions shown in Figure 3 are described below with more detailed descriptions of trends provided in each sectoral chapter.

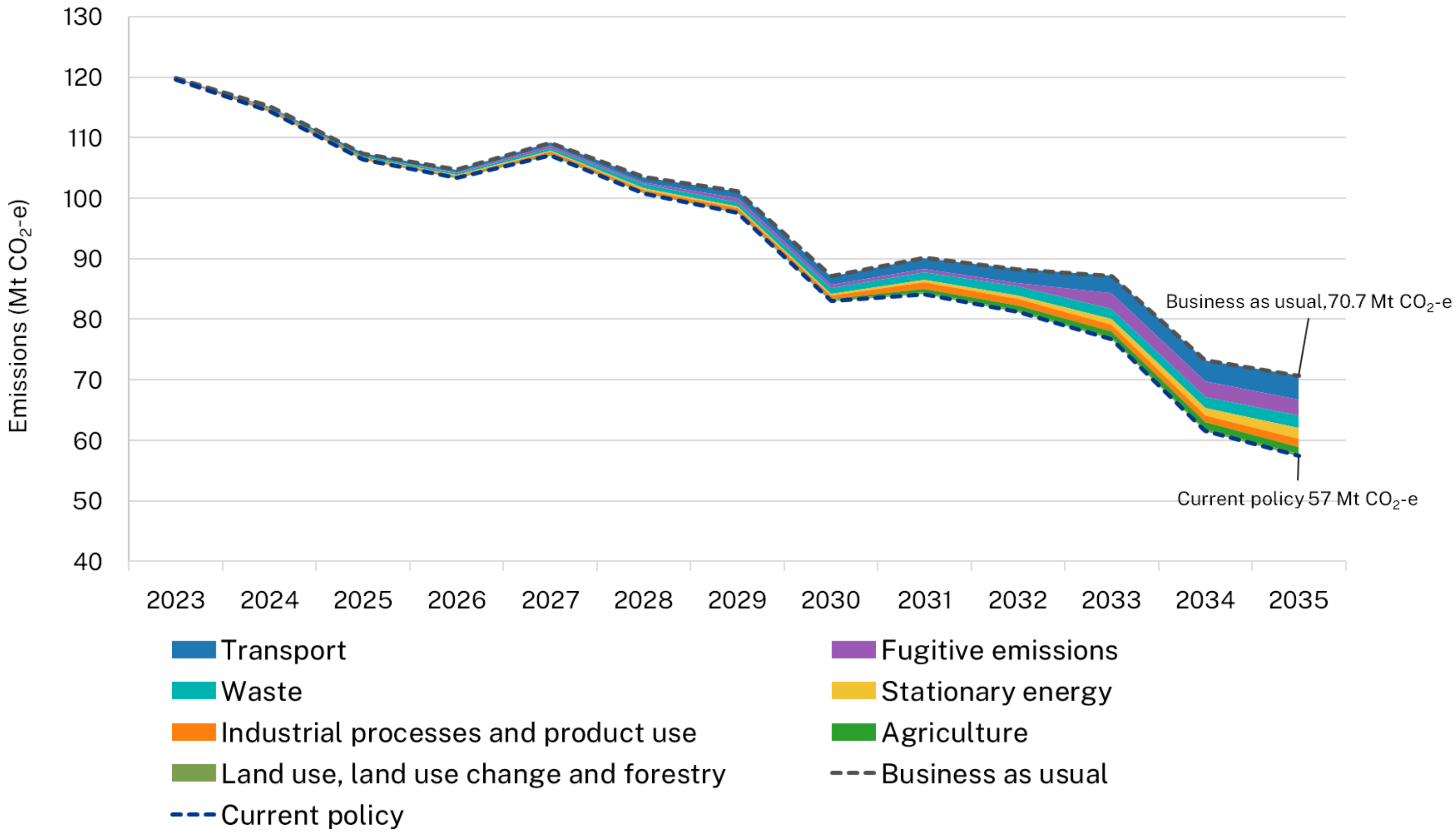

Figure 3 **Projected reduction in NSW emissions by sector over 2023 to 2035 under the program/policy abatement as currently tracking scenario**

Electricity generation: NSW electricity generation emissions are projected to reduce as the share of renewables in the National Electricity Market increases. Much of the reduction in NSW emissions over 2023 to 2035 is projected to come from electricity generation, supported by the NSW Electricity Infrastructure Roadmap (the Roadmap) (NSW Government 2020a). Based on the latest modelling (expected closure scenario), there is enough renewable energy generation build to bring forward the retirement of 2 generating units in 2029 due to the Roadmap. No further acceleration is modelled, ahead of announced closure, with all coal-fired generators assumed to be closed by 2041. Relative to 2005, sector emissions have already decreased by 26% in 2022, with projected reductions of 66% in 2030, 85% by 2035 and 98% by 2050.

Transport: There is an initial increase in transport emissions from 2022 to 2023, reflecting a post-COVID recovery in road transport and aviation. The future emission trend is dominated by reduced emissions from light-duty vehicles, due to market and policy driven uptake in electric vehicles (EVs). A slower rate of decarbonisation in freight transport and other modes sees their relative contribution to total transport emissions increase in the future. Relative to 2005, sector emissions decreased by only 2% in 2022, with a projected increase of 0.3% by 2030, and a reduction of 18% by 2035 and 72% by 2050.

Stationary energy: The energy industries/coal mining subsector sees the largest drop in in this sector, due to a reduction in production forecasts (post 2030) and assumptions for mining fleet electrification. Some abatement from electrification in buildings is supported by Net Zero Programs in the short-term, with further reductions considered feasible, supported by future program funding. Relative to 2005, sector emissions decreased by only 4% in 2022, with projected reductions of 25% in 2030, 40% by 2035 and 63% by 2050.

Fugitive emissions from fuels: Emissions are projected to increase by 2030 due to increased mining activity. A downward trend post-2030 is driven by reduced mining activity, mine closures and assumptions for feasible abatement that may be achievable on a mine-by-mine basis. Relative to 2005, sector emissions decreased by 47% in 2022, with projected reductions of 34% in 2030, 62% by 2035 and 91% by 2050.

Industrial processes and product use: Emissions are projected to decrease slowly in the medium term, primarily driven by a phase-down of hydrofluorocarbon (HFC) imports under Australian Government policies. Corporate commitments also contribute to the emissions reductions projected. Abatement is assumed in the chemicals subsector due to the Orica tertiary abatement project, however beyond 2035 the modelled pathway for the sector relies on significant or transformational process changes (that is, hydrogen direct reduced iron (DRI) processing). Relative to 2005, sector emissions decreased by only 6% in 2022, with projected reductions of 22% in 2030, 28% by 2035 and 73% by 2050.

Agriculture: Emissions are projected to decline slowly, with an assumed modest improvement in emission intensity for intensive livestock (10% by 2050). Additional abatement is assumed for enteric fermentation emissions in livestock, herd management and dietary modification/feed additives, supported by the Primary

Industries Productivity and Abatement program (DPIE 2022a). Relative to 2005, sector emissions decreased by only 7% in 2022, with projected reductions of 24% in 2030, 28% by 2035 and 38% by 2050.

Waste: Emissions projections are based on modelling that assumes targets in the Waste and Sustainable Materials Strategy will be met. This includes a 10% reduction in waste generation and a 50% reduction in organics disposed to landfill by 2030 and increasing gas capture rates across all landfills. Relative to 2005, sector emissions decreased by 22% in 2022, with projected reductions of 33% in 2030, 50% by 2035 and 40% by 2050.

Land use, land-use change and forestry: A large net sink in the sector is projected to remain, with annual fluctuations in the sector modelled to respond to changes in climate. During wetter climates, there is an increase in emission sinks and a reduction in emissions sources; during drier years, there is a decrease in emission sinks and an increase in emissions sources. NSW Government policies and programs addressing emissions in the sector 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).

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 actions under future stages of the Net Zero Plan. Longer term sector emissions projections are less certain due to assumptions regarding the sector and abatement pathways to be targeted by future actions. The longer-term projected reductions in NSW emissions by sector over 2023 to 2050, including reductions under the BAU and current policy scenarios are shown in Figure 4. New South Wales's emissions are projected to reduce to 18.2 Mt CO_2-e by 2050, indicating that further investment and breakthrough technologies and practices will be needed to address residual emissions and achieve the legislated net zero emissions target by 2050.

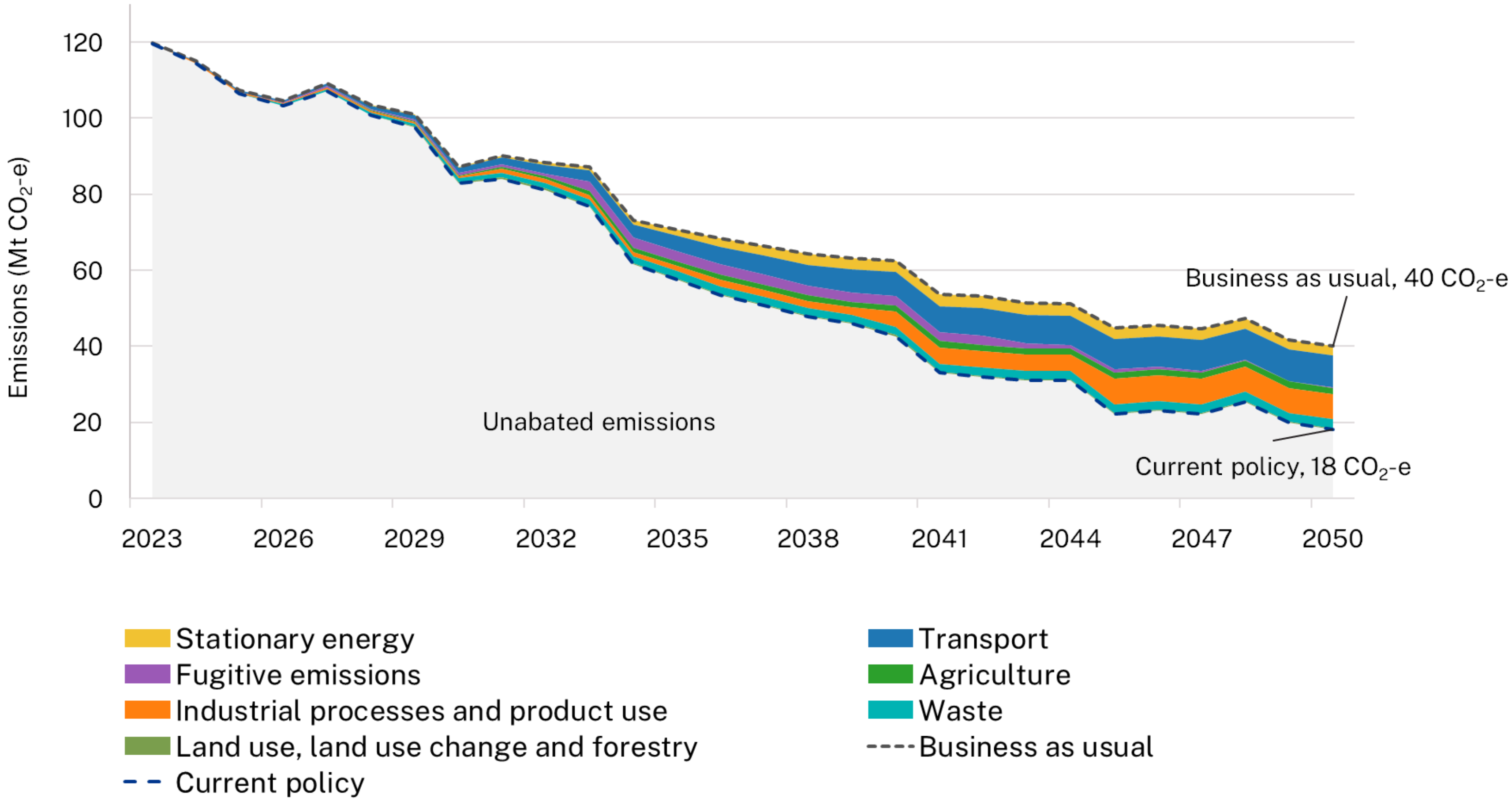

Figure 4 Projected reduction in NSW emissions by sector over 2023 to 2050 under BAU and abatement under current policy scenarios

Remaining (residual) emissions by sector for the current policy scenario are shown for selected years in Figure 5. 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.

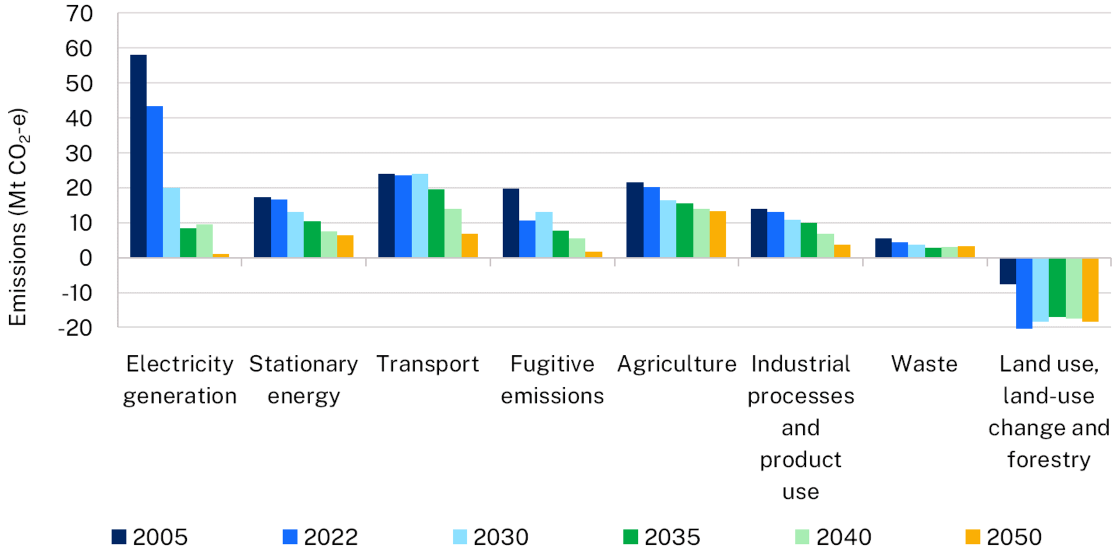

Figure 5 **NSW emissions by sector for selected years based on inventory estimates (2005, 2022) and under the current policy scenario for future years**

Comparison with the 2023 update to emissions projections

The 2023 and 2024 update to emissions projections are compared in Figure 6.

The 2024 States and Territories Greenhouse Gas Inventory (STGGI) (Cth DCCEEW 2024a) and National Inventory Report (NIR) (Cth DCCEEW 2024b) included a recalculation in the land sector that resulted in a change across the historical timeseries of NSW's greenhouse gas inventory. The recalculation was due to a revised yield model for crops and grassland, showing improved response to varying climate. For example, during La Niña periods, higher rainfall results in revised yields (crop and grass productivity increases), which in turn lead to more carbon retained in soil. These recalculations have significantly changed the base year and the projections starting point, both of which influence how NSW is tracking towards its emission reduction targets.

Compared with the NIR 2023 (Cth DCCEEW 2023e), which was used in the 2023 projections update, the 2005 base year, against which NSW's target is set, was recalculated to be 8.4 Mt CO_2-e lower. Similarly, the projections starting point in 2022 is 15.4 Mt CO_2-e lower than the previous projections update. In the 2024 update, emissions projections are 6.8 Mt CO_2-e lower in 2030 and 0.5 Mt CO_2-e higher in 2035. There are many reasons for the change in emissions compared with the previous update, with a comprehensive update to the emission projections across every sector, however, headline reasons are:

- recalculations to the STGGI changing the emissions in the base year and projections starting point year
- improved electricity sector modelling by the department that better reflects NSW policy and resulted in higher emissions in 2030 and 2035
- a reduction in abatement projected to be achieved across NSW Government policy, programs and associated market impacts, based on updated modelling using the latest available information on opportunities and marginal abatement costs.

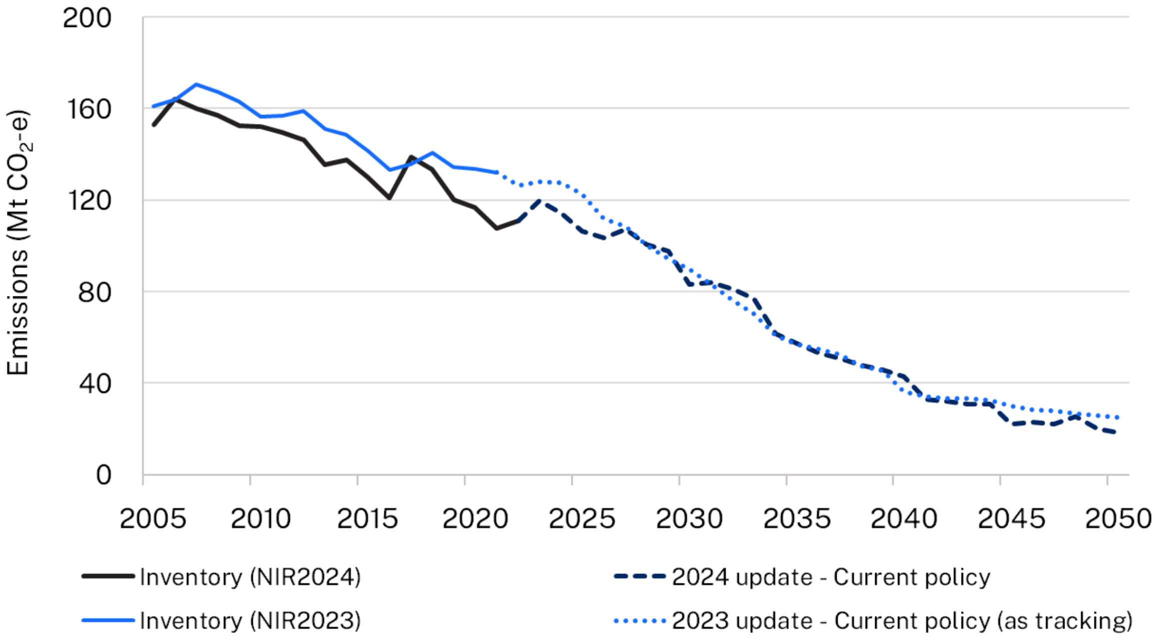

Figure 6 **Comparison of 2023 and 2024 current policy projections for NSW emissions**

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 3) (Cth DCCEEW 2024c). Emission factors used are generally consistent with the *National inventory report 2022*, published in April 2024 (Cth DCCEEW 2024b). Reporting years are financial years, which cover the 12 months ending 30 June of that year.

Table 3 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 and fugitive emissions)	–
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. They are consistent with the national emissions projections supporting Australia's reporting of progress towards commitments under the Paris Agreement (United Nations 2015).

NSW net emissions are calculated by determining the amount of direct greenhouse gas (GHG) emissions attributable to the state, including any anthropogenic removals of GHG emissions from the atmosphere due to activities in New South Wales.

Emissions are projected from 2023 to 2050, with reference made to inventoried emission estimates for 1990 to 2022, (latest emissions inventory year published at the time the projections were prepared) (Cth DCCEEW 2024a).

Indirect emissions (scopes 2 and 3), lifecycle carbon and embodied carbon are not addressed in the business as 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 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.

Many of the Net Zero Plan Stage 1 programs have been redesigned, re-profiled or pivoted from the original design. Updates to the emissions abatement trajectory are made to account for these changes, based on the latest information available at the time. Therefore, the abatement projected for net zero programs is generally based on one of the following:

- the original emission projections developed for cost–benefit analysis (CBA) in program design and business cases

- updated emission projections due to completed grant funding rounds, 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. The projections also include NSW Government actions under future stages of the Net Zero Plan. These programs and policies are summarised in Table 4.

Table 4 **Net zero programs and related policies considered in the 2024 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	*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
Abatement from committed funding under future stages of the Net Zero Plan	No policies or programs are yet designed	All sectors with residual emissions (excluding electricity and LULUCF)All sectors with residual emissions (excluding electricity and LULUCF)

Method to evaluate abatement under future stages of the Net Zero Plan

Funding for the Net Zero Plan will continue beyond stage 1, with future initiatives aimed at reducing emissions and promoting clean energy supported by the NSW Government's Climate Change Fund (CCF). Emission reduction estimates for future stages of the Net Zero Plan are based on top-down modelling, assuming funding commitments of $150 million per annum under the CCF over 2031 to 2050.

A private sector co-investment ratio of 1:4 is assumed, with the total funding pool covering capital and operating expenditures (minus administration costs assumed at 5%). Unspent funding is assumed to be carried over to the next year. The annual budget may be amended within the total funding envelope to enable large capital intensive industrial-scale decarbonisation projects.

Funding for future stages would be used to design programs and policies to target sectors with significant residual emissions post-2030, using existing (that is, commercially ready) and future potential decarbonisation solutions (that is, solutions that are current in research and development or demonstration).

The potential decarbonisation solutions are identified using the NSW Government's Carbon Valuation Tool (Deloitte 2024). The Carbon Valuation Tool includes decarbonisation solutions that could have the highest impact on reducing NSW's emissions, based on relative marginal abatement costs (that is, the cost of reducing one tonne of carbon emissions ($/t$CO_2$-e)), deployment trajectories and NSW's emission reduction targets. Decarbonisation solutions that can address residual emissions in 2030 and beyond are extracted from the Carbon Valuation Tool and ranked by marginal abatement cost (MAC).

The maximum abatement potential for each decarbonisation solution, also extracted from the Carbon Valuation Tool, is based on emissions addressable by 2050 and an S-curve deployment rate, if applicable. The S-curve deployment rate is assumed for economy-wide decarbonisation solutions because it encapsulates the typical solution adoption lifecycle: slow initial uptake due to barriers, rapid growth as those barriers are overcome, and eventual saturation as the solution reaches its market potential. This nonlinear approach more realistically accounts for the technological, economic, and societal factors influencing solution penetration over time.

The maximum abatement potential exported from the NSW Carbon Value Tool is summarised in Table 5 by sector.

Table 5 **Maximum abatement potential (Mt CO_2-e) for 2031, 2035 and 2050**

Sector	2031	2035	2050
Agriculture	1.1	2.9	3.3
Electricity	4.0	2.2	1.2
Fugitive emissions	0.1	2.1	1.6
IPPU	2.2	2.2	10.0
LULUCF	0.5	2.7	7.4
Stationary energy	1.1	2.0	4.3
Transport	1.2	4.1	13.8
Waste	0.7	1.7	3.7
Total	**10.9**	**20.0**	**45.2**

Some of the identified decarbonisation solutions may not be currently ready for full scale deployment, requiring for example:

- significant advancements in technology and infrastructure
- approvals and compliance with environmental and safety standards
- large upfront investment, especially for early-stage technologies (CSIRO 2023).

The technology readiness level (TRL) for each solution and the expected year that the solution is ready for implementation is taken from the Climate Change Authority's (CCA) Sector Pathways Review, commissioned by the Australian Parliament (CCA 2024), categorised as research and development, demonstration, and commercial.

The shortlisted decarbonisation solutions for this analysis and their associated CCA TRL are shown in Table 6.

Table 6 **Decarbonisation solutions selected for funding future stages of the Net Zero Plan**

Sector	Solution	MAC	Readiness Level (CCA 2024)	FY for implementation
Agricultural	Herd management	Low	Commercial	2024
	Feed supplements	High	Research and development	2024
Fugitive	Ventilation air methane oxidation (underground mines)	Middle	Demonstration	2035
IPPU	Aluminium smelting – inert anodes	High	Demonstration	2035
	Cement produced with alternative raw material	Middle	Commercial	2030

Sector	Solution	MAC	Readiness Level (CCA 2024)	FY for implementation
	Green ammonia	High	Demonstration	2035
	Direct reduced iron	High	Demonstration	2040
Stationary energy	Household appliances electrification and efficiency	High	Commercial	2030
	Household heat pumps – space and water	Middle	Commercial	2030
	Mining vehicle electrification	High	Demonstration	2030
Transport	Heavy-duty rail – fuel switch	Low	Demonstration	2030
	Light-duty Battery Electric Vehicle	Middle	Commercial	2024
	Heavy-duty Battery Electric Vehicle	High	Commercial	2024
	Sustainable aviation fuel	High	Research and development	2030
Waste	Methane capture from landfills – power generation	Low	Commercial	2030

The maximum abatement potential for each solution is adjusted based on an assumed abatement efficiency that corresponds to the TRL, with the assumed abatement efficiencies for each of the CCA TRL categories shown in Table 7. For example, for solutions currently in the research and development phase, the abatement efficiency is assumed to be 30% in 2031 to 2035, advancing to 45% in 2036 to 2040, and reaching 65% in 2041 to 2050. Applying these abatement efficiencies accounts for less mature solutions requiring funding for research, development and deployment, resulting in less actual abatement being achieved for the same investment.

To calculate the annual emissions abatement achieved for each solution, the maximum abatement potential from the Carbon Valuation Tool is multiplied by the respective abatement efficiency.

Table 7 Assumed abatement efficiency for CCA TRL categories 2031 to 2050

Readiness level	2031–2035	2036–2040	2041–2050
Research and development	30%	45%	65%
Demonstration	45%	65%	80%
Commercial	100%	100%	100%

To calculate the annual abatement cost for 2031 to 2050, the adjusted maximum abatement potential for each shortlisted solution is multiplied by the respective MAC. In the case where total abatement cost exceeds the available funding, solutions with lower MAC are preferred for full deployment while solutions with higher MAC have a reduced deployment.

It is noted that some solutions included in Table 6 may attract funding under future stages of the Net Zero Plan but the maximum abatement potential for these solutions may already be considered under other policies, programs or action, and therefore excluded.

Modelling emissions reduction for future funding is considered highly uncertain, due to uncertainty in the direction of future policies and programs, the pace of technological advances, and costs for the potential decarbonisation solutions. This analysis will be regularly updated, incorporating the latest information on MAC, technology advancement and TRLs.

Consideration of Safeguard Mechanism reform

The Australian Government'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 surrender of Australian carbon credit units (ACCUs) or Safeguard Mechanism credits (SMCs) (Cth DCCEEW 2023a).

How each facility in New South Wales will meet their obligations is not known at this stage. However, there are onsite abatement potential assumptions across multiple sectors in NSW's emissions projections. A proportion of the declining emissions baseline obligations for NSW facilities is therefore accounted for in NSW's projections, assumed to be met through this onsite abatement potential.

The remaining proportion of the declining emissions baseline obligations will need to be met through surrendering ACCUs or SMCs. This proportion is not accounted for in NSW's projections because:

- NSW's net emissions, for the purposes of tracking to targets, are calculated by determining the amount of direct emissions attributable to the state, including any anthropogenic emission removals due to activities in the state

- there is no current way for NSW to track where offsets used to meet declining emissions baseline obligations were generated
- there is no current framework or agreement for the transfer of mitigation outcomes between Australian jurisdictions and the corresponding adjustment to state accounts.

Peer review and future improvements

The assumptions, inputs, and results of the BAU and current policy emissions projections in the 2023 update were subject to peer review by independent expert reviewers external to NSW Government (ARUP 2024a). 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.

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 (that is, manufacturing stationary energy, agriculture, and LULUCF) were identified as having a lower level of confidence. This feedback is addressed by removing some assumptions for abatement opportunity and presenting a more cautious 'current policy' scenario.

The assumptions, methods and inputs used for the 2024 update are unchanged across most sectors and, therefore, were not subject to additional independent peer review.

The exceptions are for the agriculture and land sectors and the methodologies employed for these sectors were tested with subject matter experts within the NSW Department of Primary Industries and Regional Development.

A formal review and consultation process will continue across all sectors for the 2025 projections update.

Electricity generation

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

The 2024 current policy projections represent a significant change in modelling approach, with the projections no longer directly referring to external modelling prepared by AEMO Services Limited, the Consumer Trustee (e.g. the *2023 Infrastructure investment objectives report* (IIO) or the Australian Energy Market Operator (AEMO) (for example, *2022 Integrated System Plan* (ISP)).

Emission projections are now based on internal departmental modelling.

Emission projections are presented for a current policy scenario only, accounting for both the *Electricity Infrastructure Roadmap* (NSW Government 2020a) and the *Energy Security Safeguard* (NSW Government 2020b), as well as an early representation of the Australian Government's Capacity Investment Scheme (CIS). While NSW Government policies are designed to support the acceleration of the state's electricity sector transition, developing a BAU scenario that accounts for national emissions reduction targets and the CIS, but not NSW's Roadmap, is not possible and therefore no longer presented.

Summary of the emissions trends

The electricity sector emissions are presented in Figure 7, showing inventoried emissions to 2022 and projected emissions for 2023 to 2050. Emissions from the sector have grown steadily from 1990 to a peak in 2008, rising in line with population growth and increased electricity consumption for the state. Emissions then decline in 2015, with a fall in consumption also evident, due to energy efficiency, increasing prices, growth in rooftop solar and industrial facility closures (Sandiford et al. 2015). This is followed by a short-term increase from 2016 to 2019; however, since 2019 emissions have steadily declined, despite increasing consumption, due to the growing share of renewables. The closures of the Wallerawang Power Station in 2013–14 and the Liddell Power Station in 2022–23 has contributed to the declining emissions.

In 2022, the electricity sector represented 39% of NSW emissions, a decline of 26% on 2005. Under the current policy scenario, emissions are projected to be 19.9 Mt CO_2-e in 2030 (66% below 2005 levels) and 8.4 Mt CO_2-e in 2035 (85% below 2005 levels).

Compared with the 2023 update, the latest projections for the sector are 4.2 Mt CO_2-e higher in 2030. The updated modelling for the 2024 update is considered to better reflect NSW policy and removes a carbon budget constraint that was implicitly applied in previous modelling.

The revised trend presented in Figure 7 shows higher emissions from 2025 to 2035 compared to previous modelling. In the latest update, Eraring Power Station is modelled to operate until 2027, based on an agreement with the NSW Government (NSW Government 2024), whereas in previous projections it was modelled to operate until 2025. Emissions decline following Eraring's closure but are still higher compared to previous modelling. This is due to less accelerated closure of coal generators compared to the 2023 projections update, due to the removal of the carbon budget constraint in the latest modelling. The methodology and assumptions for the updated modelling are summarised in subsequent sections.

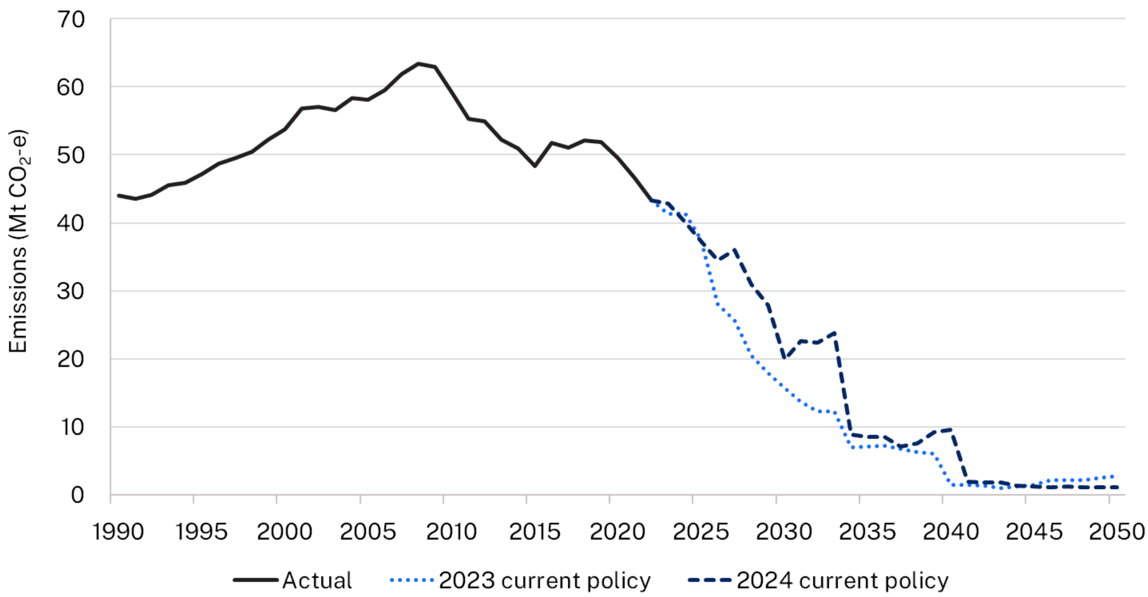

Figure 7 **NSW electricity generation emissions as inventoried (1990 to 2022) with current policy emissions projections (2023 to 2050)**

Methodology and assumptions

The internal departmental modelling used PLEXOS, an industry standard market simulation engine, also used by AEMO to simulate the ISP model.

The modelling scenario uses the AEMO 2024 ISP PLEXOS Step Change model (AEMO 2024) as the starting point, which in turn uses the assumptions from AEMO's *Inputs, assumptions and scenarios report* (AEMO 2023). The model is updated using AEMO's July 2024 Generation Information Database, which includes, at the time of modelling, the latest information on anticipated and committed projects as well as up-to-date estimates of commercial operation dates.

The internal departmental modelling deviates from the ISP model in 2 key ways:

- no emissions target is applied to the model's optimisation
- coal closures are not determined by carbon budget.

Coal closures are initially based on current announced closure dates, as this represents the latest and most accurate information on closures. A unit of a coal power station is closed ahead of its announced closure date, if the statewide coal fleet capacity factor drops below set thresholds in 2 consecutive model years. Capacity factor thresholds are set based on historical observations.

Using this methodology, the modelling assumes there is enough VRE generation build to bring forward the retirement of 2 NSW coal units in 2029, ahead of their announced closure dates of 2033, due to the Roadmap targets and the CIS. The modelling assumes there is no policy mechanism post 2030 that incentivises sufficient VRE build to accelerate coal generator retirements.

Considerations for projection updates

The use of a single demand projection for NSW (2024 ISP Step Change demand projection) is noted limitation in the model. Due to the high level of uncertainty in future demand changes, future modelling may consider more than one demand scenario. It is expected that current policy modelling for New South Wales will be updated for the next AEMO ISP update.

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). Subsectors include energy industries (for example, diesel combustion in coal mining), manufacturing industries and construction (for example, gas and diesel combustion), primary industries (for example, diesel used in agriculture, forestry and fishing) and commercial/institutional and residential (for example, gas and diesel combustion in buildings).

Summary of the emissions trends

Inventoried emissions (1990 to 2022) and emissions projections (2023 to 2050) for the stationary energy subsectors are shown in Figure 8 for the business as usual (BAU) scenario and Figure 9 for the current policy scenario.

The 2 largest contributors to sectoral emissions are the manufacturing industries and construction, and the energy industries. In 2022, the manufacturing industries and construction sector accounted for 6.8 Mt CO_2-e (41%), and the energy industries sector contributed 3.6 Mt CO_2-e (22%). Residential contributed 2.4 Mt CO_2-e (15%) and agriculture, forestry and fishing contributed 2.2 Mt CO_2-e (13%). The commercial/institutional sector was the smallest contributor with 1.6 Mt CO_2-e (10%).

In 2022, the manufacturing industries and construction sector reduced greenhouse gas (GHG) emissions by 2 Mt CO2-e (23%) from 2005 levels. The reduction between 2005 and 2022 was largely driven by decreases in emissions from the iron and steel industry, which is the largest contributor to emissions within this subsector.

Figure 8 shows that BAU emissions are projected to decline slowly from 14.0 Mt CO_2-e in 2023 to 13.3 Mt CO_2-e in 2030, 12.1 Mt CO_2-e in 2035 and 9.0 Mt CO_2-e in 2050. The longer-term decrease is most evident in energy industries, reducing from 3.8 Mt CO_2-e in 2023 to 0.4 Mt CO_2-e in 2050, which is mainly due to decreasing production in the coal mining sector. BAU emissions from manufacturing industries and construction show little decline, with 4.0 Mt CO_2-e in 2023 and 3.9 Mt CO_2-e in 2050. Meanwhile, emissions in commercial and residential buildings as well as agriculture, forestry and fishing show a slow decline.

Between 2022 and 2023, there is a drop for manufacturing industries 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).

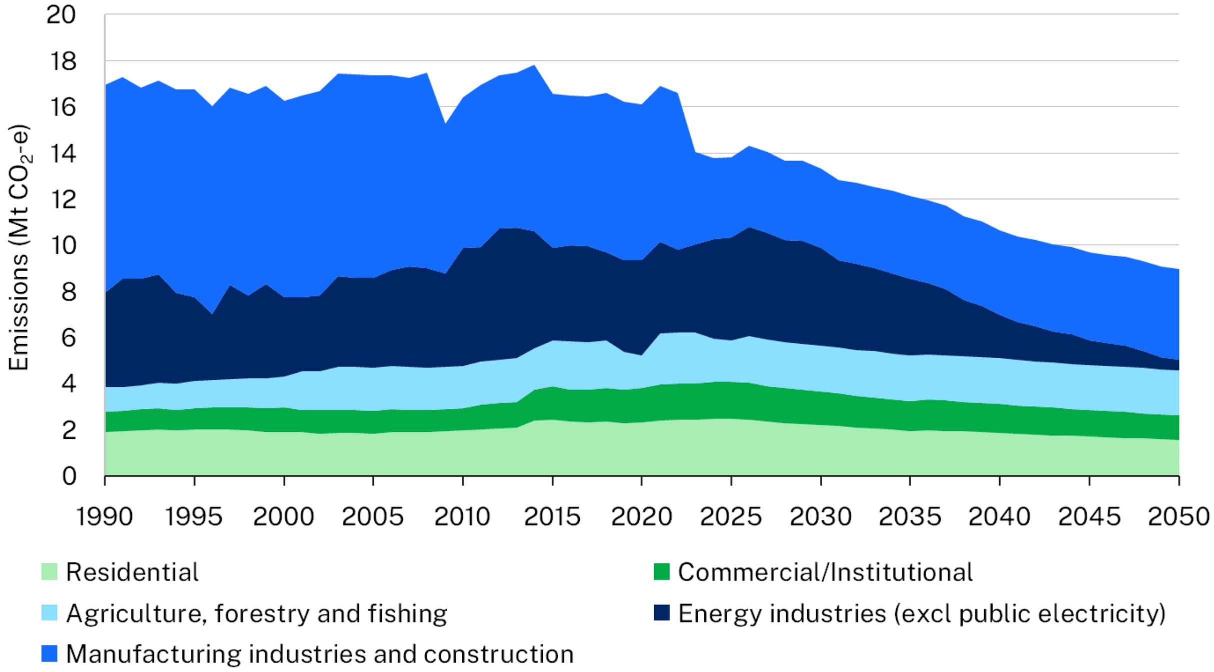

Figure 8 **Stationary energy emissions by subsector showing inventory estimates (1990 to 2022) and BAU emissions projections (2023 to 2050)**

Figure 9 shows the increased emission reductions under current policy, mainly in energy industries as well as commercial and residential buildings. For energy industries, the reduction is mainly in coal mining, with abatement assumed from fuel switching and electrification, supported by net zero programs such as the Net Zero Industry and Innovation Program (NZIIP) and further leveraged by regulatory requirements, for example, the Australian Government's Safeguard Mechanism reforms and the Environment Protection Authority's climate change policy and action plan (CCPAP, EPA 2023a, 2023b).

For commercial and residential buildings, the reduction is projected to come from fuel switching and electrification, supported by existing net zero programs (Business decarbonisation support, Safeguard Acceleration Program, Net Zero Buildings Initiative and the State Environmental Planning Policy (Sustainable Buildings) (see Table 4). Under future stages of the Net Zero Plan, a proportion of funding is also assumed to be allocated to programs that increase abatement in buildings.

Methodology and assumptions are discussed in subsequent sections.

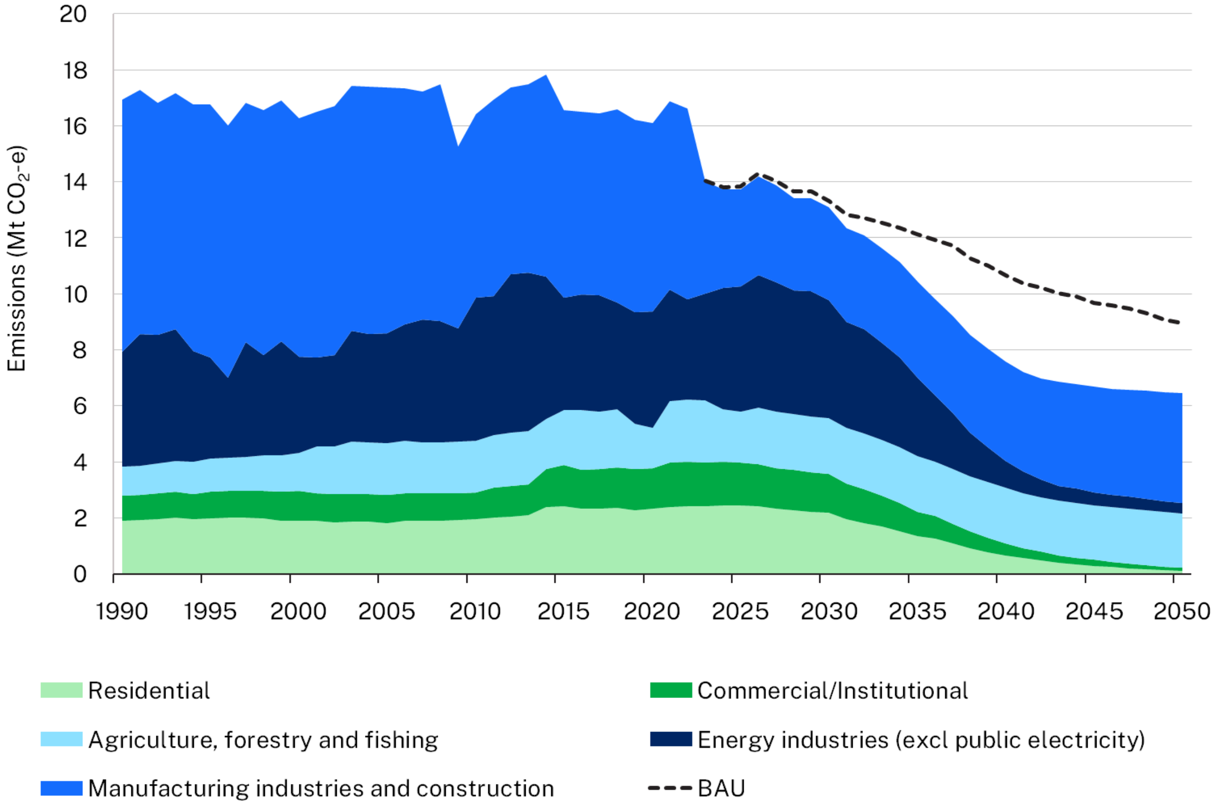

Figure 9 **Stationary energy emissions by subsector showing inventory estimates (1990 to 2022) and current policy emissions projections (2023 to 2050)**

Methodology and assumptions

Energy industries (coal, gas)

Coal mining

Detailed GHG emissions data was obtained from the Clean Energy Regular for each coal mine in New South Wales based on facility reporting under the Australian Government's National Greenhouse and Energy Reporting Scheme (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 (including non-road fuel consumption) and mobile activities were grouped. 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 2022–23 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 NSW Resources Group in the Department of Primary Industries and Regional Development (previously the Minerals, Exploration and Geoscience group).

For the 2024 projections update, future ROM coal production forecasts were developed for 3 scenarios by the NSW Resources Group (November 2024). Fugitive and stationary energy emissions projections were thus developed for the 3 scenarios and one scenario was selected to be representative for the sector. Further detail on the scenarios can be found in the 'Coal mining fugitives' section of the 'Fugitive emissions from fuels' chapter.

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.

Fugitive and stationary energy emissions projections for transmission and distribution pipelines and storage facilities were based on NGERS data. This includes emissions from venting, flaring and fugitive leaks. The NGERS data for each type of emission over the period FY 2016 to FY 2023 were averaged and held constant out to 2050. The averages were taken as there is insufficient information on these facilities to perform a more detailed calculation of future projections.

The projections also included the 2 production developments, Port Kembla Energy Terminal (PKET) and the Narrabri Gas Project (NGP), which were assumed to commence operations in FY 2026 and FY 2028, respectively. Data for these 2 projects were obtained from the EIS, available in the public domain (DPE 2022d). Both EIS emissions data were based on a maximum gas production scenario. EIS emissions were modelled based on 100 petajoules per annum (PJ p.a.) delivery for PKET and 73 PJ p.a. delivery for NGP.

An external supply/demand analysis was performed using the Australian Energy Market Operator's (AEMO) *2021 Gas statement of opportunities* (GSOO) central case (Scenario 1) (AEMO 2021). This provided a forecast of future liquefied natural gas (LNG) import and processing requirements at PKET and production from NGP out to 2040. This data was used to then scale down the emissions from PKET and NGP.

The supply/demand analysis indicated a increase from 30 to 100 PJ p.a. over a 15-year period at PKET and a maximum delivery of 40 to 50 PJ p.a. from NGP in most years.

Given the current status of the PKET and NGP projects, the production and emissions projections have been unchanged until more accurate data can be obtained.

To estimate future stationary energy emissions for NGP, the BAU scenario assumed that onsite power demand would be met by importing grid electricity. The NSW electricity grid will become increasingly decarbonised providing further abatement for the project. This assumption has been confirmed by the project proponent.

Manufacturing industries and construction

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

- integrated the latest NGERS data, EIS information, CSIRO data, IBISWorld commodity data 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 emissions reduction commitments are made for facilities covered under the Safeguard Mechanism, potential onsite abatement actions to reduce emissions are counted under the current policy projections. 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 scenario.

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 2024d) 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 2029 for each commodity or sector from market analyst reports from IBISWorld (IBISWorld 2024). 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 2029. For future emissions to 2050, a linear trend was assumed starting with the 2029 emissions.

The following changes were made in this latest update projections:

- forecasts for steel and aluminium production were updated with the 2024 Office of the Chief Economist *Resources and Energy Quarterly* (OCE REQ)
- commodity revenue projections were updated with 2024 IBISWorld data
- long-term forecasts for major commodities, including steel, aluminium and cement over the period 2030 to 2050 were improved using recent CSIRO data (CSIRO 2023)
- in the chemical subsector, Qenos is excluded from 2024 onwards due to closure of the Botany facility
- BlueScope's corporate abatement was reduced due to the cancellation of coke oven gas (COG) injection
- Tomago Aluminium's corporate abatement commitment was updated on waste heat recovery
- Boral's corporate abatement was updated to include its commitment to fuel switching in Boral Cement Works Berrima
- 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 iron and steel production process, and COG-related emissions. Ongoing steel production from BlueScope Port Kembla and InfraBuild Steel Mill Sydney is included in 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 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 2023 is assumed to be constant to 2050.

For 2024 to 2029, data from the OCE June 2024 REQ forecast (DISR 2024a) and March 2024 REQ forecast (DISR 2024b) (covering 2027 to 2029) are used to project iron and steel production in New South Wales, as shown in Table 8.

Table 8 Office of the Chief Economist forecasts for iron and steel as a percentage change in production (2024 to 2029)

2024	2025	2026	2027	2028	2029
–6.54%	4.15%	0.00%	–2.31%	2.42%	0.33%

From 2030 to 2050, a domestic growth scenario is assumed with new production expansion continuing. The steel production growth rates are derived from an average extrapolation of CSIRO Rapid Decarbonisation (CRD) and CSIRO Stated Policies (CSP) in CSIRO's *Pathways to Net Zero Emissions* (CSIRO 2023).

BlueScope's commitments for onsite abatement are outlined in Table 9, 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 9 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
Hot blast gas waste heat recovery	2027–2050	Reduction of approximately 11,000 t CO_2-e p.a.	Company commitment
Alternative fuel (use of charcoal produced from forestry waste)	2035–2050	Estimated reduction of approximately 25,000 t CO_2-e p.a.	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 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 2024 to 2029, a combination of data from OCE REQ June 2024 (DISR 2024a) and OCE REQ March 2024 (DISR 2024b) were used to forecast aluminium production in New South Wales, as shown in Table 10.

Table 10 **Office of the Chief Economist forecasts for aluminium percentage change in production (2024 to 2029)**

2024	2025	2026	2027	2028	2029
2.29%	–0.37%	0.00%	0.00%	0.00%	0.00%

From 2030 to 2050, a domestic growth scenario is assumed with new production expansion continuing. The aluminium production growth rates are derived from an average extrapolation of CSP and CRD scenarios in CSIRO (2023).

Similar to the IPPU aluminium production emissions projections, the main BAU scenario combines the OCE projections (2024 to 2029) and the domestic growth scenario projections (2030 to 2050). The 2023 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 2024a). 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 NGERS 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 2023 to 2050, which is responsible for a drop in emissions in 2023 (rather than any assumed abatement). The source of the discrepancy will continue to be investigated.

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

Table 11 **Abatement assumed based on Tomago's emissions reduction commitments**

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
System efficiency improvement	2027–2050	Not public	Transformative Industry Projects (TIP) scoping studies

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 2023 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 2023 to 0.385 Mt p.a. in 2070–71. This assumption is an approximation based on the economic conditions and the 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 2024 to 2029, IBISWorld 2024 revenue forecast (IBISWorld 2024) for chemical industry is used as a proxy for growth, shown in Table 12. This replaced the previously used chemical industry emissions projections (DISER 2020a). The IBISWorld 2024 revenue forecast is a better proxy for BAU growth (latest Australia's chemical industry emissions projections included emission reduction projects in NSW).

For the period 2030 to 2050, published information from Orica describes an additional nitric acid plant that will be operating in 2030. It is assumed that production of nitric acid will grow linearly to reach 0.605 Mt p.a. in 2070–71. The maximum capacity is 0.605 Mt p.a. following the expansion (Orica 2022a). Orica's commitments for onsite abatement are outlined in Table 13.

Table 12 IBISWorld revenue growth rates for chemical industry, percentage change in production (2024–2029)

2024	2025	2026	2027	2028	2029
–6.4%	–1.6%	5.2%	4.6%	2.3%	3.0%

Table 13 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

Qenos is excluded from 2024 due to the announced closure of its Botany facility. Qenos Botany plant has not operated since February 2023. Qenos is the only emitter in polymer production.

Chemicals – other chemical manufacturing

Other chemical manufacturing represents a small portion of emissions in this sector. The emissions projection is forecast based on IBISWorld 2024 revenue forecast (IBISWorld 2024) for chemical industry. For 2030 to 2050, a compound annual growth rate (CAGR) of 1.2% is assumed by taking an average of 2024 to 2029 revenue growth rates.

Chemicals – discrepancy between NGERS and STGGI

NGERS emissions for the chemicals sector account for only about 40% of the STGGI (Cth DCCEEW 2024a) 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 (for example, 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. This accounts for the drop in emissions from this subsector from 2022 to 2023, 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, and other non-metallic minerals were forecast using IBISWorld revenue forecast data averaged over the above subsectors (IBISWorld 2024). After 2029, a linear regression is applied to extend the projection to 2050. The changes in production in these subsectors to 2029 are shown in Table 14.

Table 14 IBISWorld revenue forecast data for non-metal minerals, percentage change (2024 to 2029)

Industry	2024	2025	2026	2027	2028	2029
Glass	–2.90%	1.30%	0.90%	1.30%	2.30%	2.00%
Ceramics	–4.90%	0.70%	0.70%	1.90%	–0.30%	0.10%
Other	–1.70%	2.70%	3.30%	2.60%	0.90%	0.80%

Emissions for cement, lime, plaster and concrete product were forecast using cement production forecasts for Australia as a proxy (CSIRO 2023), assuming changes in sector emissions are proportional to changes in production. Boral's commitments for onsite abatement are outlined in Table 15.

Table 15 **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, 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)	2023–2050	Assumed to reduce ~90,000 to 120,000 t CO_2-e p.a.	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 2024), shown in Table 16. Emissions projections were calculated using the same methodology as the non-metal minerals subsector.

Table 16 **IBISWorld revenue forecast data for pulp, paper and print, percentage change (2024–2029)**

Industry	2024	2025	2026	2027	2028	2029
Pulp, paper and print	4.3%	4.0%	2.1%	-4.5%	2.0%	1.0%

Food processing, beverages and tobacco

The NGERS stationary energy emissions for Manildra's Shoalhaven starch are based on the expansion of flour production. Under its existing approval, from 2022 Manildra Group proposes to increase production by 37% to 1,300,000 tonnes p.a. of flour throughput (GHD 2021). It is assumed that flour production from Shoalhaven Starches will grow linearly to 1,300,000 tonnes p.a. in 2060 (this is a forecast assumption, not stated in the GHG report). Manildra's commitments for onsite abatement are outlined in Table 17, this update further separates its emission reduction programs to co-generation and heat recovery upgrades.

Other food, beverages, tobacco manufacturing 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 2024), shown in Table 18. Emissions projections were calculated using the same methodology as the non-metal minerals subsector.

Table 17 **Abatement assumed based on published commitments**

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
Alternative fuel – Manildra	2024–2050	Assumed to reduce 14,436 t CO_2-e p.a. from gas	Company commitment

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
Shoalhaven Starches site co-generation		co-generation to replace coal (GHD 2021)	(Manildra 2022)
Shoalhaven Starches heat recovery upgrades	2028–2050	Assumed to reduce 95,266 t CO_2-e p.a. (media release)	Cth. Powering the Regions Fund

Table 18 **IBISWorld revenue forecast data for food processing, beverages and tobacco (2024–2029)**

Industry	2024	2025	2026	2027	2028	2029
Food processing, beverages and tobacco	–0.07%	0.92%	1.18%	1.31%	0.48%	1.95%

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 19 (IBISWorld 2024).

Table 19 **IBISWorld revenue forecast data for other manufacturing, percentage change (2024–2029)**

Industry	2024	2025	2026	2027	2028	2029
Other manufacturing	–7.6%	–2.6%	–0.9%	0.5%	0.3%	0.6%

For construction, growth forecasts were based on the Low Emissions Building Materials Program's forecast for 2024 to 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 20.

Table 20 **Low Emissions Building Materials Program growth forecast for construction, percentage change (2024–2029)**

Industry	2024	2025	2026	2027	2028	2029
Construction	–0.06%	2.87%	5.04%	–0.13%	1.04%	1.65%

For other metal mining such as silver, lead and zinc, and gold mining, average of IBISWorld revenue growth rates for silver, lead and zinc ore mining and gold mining were used as a proxy (IBISWorld 2024), shown in Table 21.

Table 21 **IBISWorld revenue forecast data for other metal mining, percentage change (2024–2029)**

Industry	2024	2025	2026	2027	2028	2029
Other metal mining	–1.2%	2.25%	–3.4%	0.55%	–0.3%	–2.3%

For textiles, the IBISWorld revenue growth rates for synthetic and natural textile manufacturing were used (IBISWorld 2024), as shown in Table 22.

Table 22 **IBISWorld revenue forecast data for textiles, percentage change (2024–2029)**

Industry	2024	2025	2026	2027	2028	2029
Textiles	–0.7%	2.5%	–0.9%	0.4%	–2.1%	–5.0%

As discussed previously for the chemicals subsector, NGERS emissions data for this subsector accounts for 40% or less of the STGGI (Cth DCCEEW 2024a) 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 2023 to 2050, which is responsible for a drop in emissions in 2023 (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 and fishing) and commercial/institutional and residential sectors. These sectors accounted for total emissions of about 6 Mt CO_2-e in 2022, 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 2022 STGGI (Cth DCCEEW 2024a). BAU projections for the other sectors were based on the NSW contribution to national emissions for this subsector (Cth DCCEEW 2024a) and Australia's emissions projections (Cth DCCEEW 2024c).

For post-2040 emissions, linear forecasts were used with the consideration of a progressive, lower carbon BAU trajectory. Emission reductions for buildings include strategies from the Australian Government such as improving energy performance, residential and commercial electrification, while NSW Government programs are excluded in BAU.

Changes in emissions since last year's projection update

Figure 10 compares the 2023 and 2024 BAU projections. The reduction in BAU emissions in the 2024 update is evident across all sectors, a result of revised production forecasts, closure of the Qenos facility and assumptions for improved energy performance in buildings.

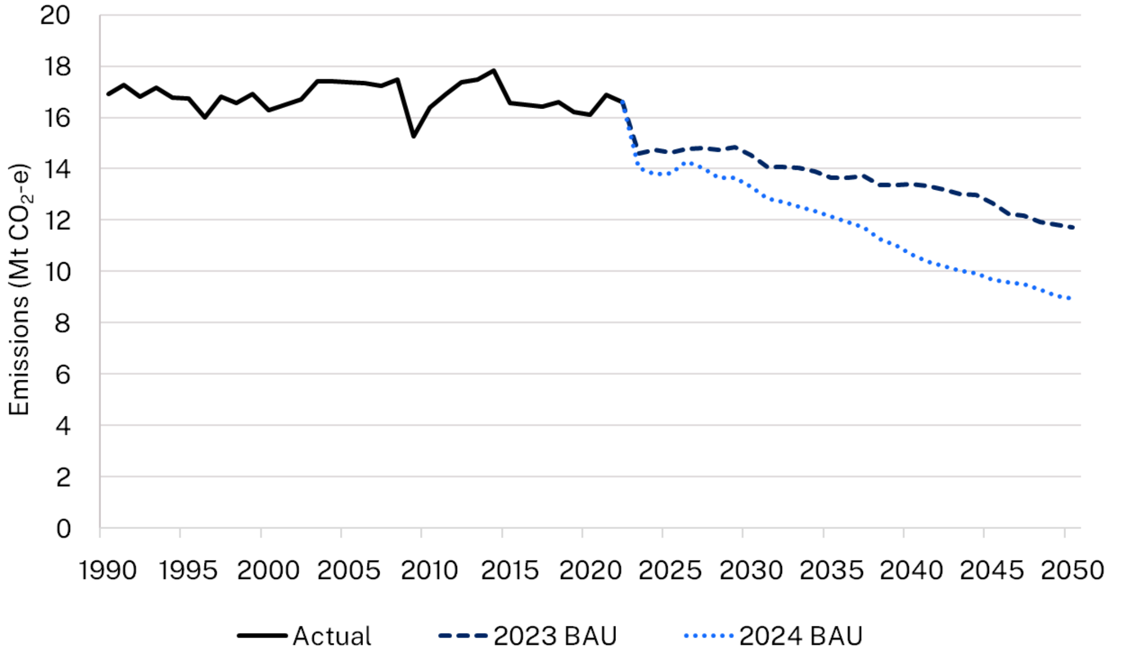

Figure 10 **Comparison of 2023 and updated 2024 BAU emissions projections for stationary energy**

Current policy assumptions

Abatement in this sector is projected to come from fuel switching and electrification, supported by net zero programs and related policies.

Net Zero Plan programs

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 Independent Pricing and Regulatory Tribunal. Emission reductions are assigned to the commercial/residential sectors. The Sustainable Government, Sustainable Council, and Sustainable Advantage programs continue to support emissions reductions within the 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.

Potential projects funded by the High Emitting Industries stream of NZIIP target emission reductions in manufacturing industries and in mining. An estimate of potential abatement from these projects is based on a statistical analysis of the abatement potential from each project and the probability of implementation. Projects target electrification (battery electric vehicles), energy efficiency and replacement fuels.

Other Government action and policy

Open-cut mines operating post-2042 are assumed to gradually replace non-road diesel equipment with clean technology starting in 2033. The abatement to be achieved post-2032 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.

The Sustainable Building SEPP (NSW Government 2022e) sets sustainability standards for residential and non-residential development. It 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. The emissions reduction is assumed based on no gas or diesel usage in new buildings from 2035 to 2050. Emissions reductions are estimated using the natural gas consumption forecasts from the 2024 Commercial Building Baseline Study as a proxy (Cth DCCEEW 2024e). This gas consumption forecast aligns with the AEMO Step Change scenario (ISP 2024), which includes projected fuel mix, number of gas connections, average gas use per connection, rooftop photovoltaic capacity and output, and building stock growth. While some gas efficiency improvements are expected, particularly in new buildings, most of this change is driven by electrification.

Additionally, emissions reductions in the residential building sectors due to reduced gas consumption are supported by the NSW Government's BASIX program. This includes reducing water and energy usage and improving thermal performance for new residential dwellings (DPIE 2023). The year-on-year emissions reduction is derived from the total gas saving under BASIX 2022 cost-benefit analysis. It is assumed the gas consumption savings and associated emissions reduction will increase linearly from 2023 to 2070.

The abatement that is projected to be achieved for each subsector is shown in Figure 11.

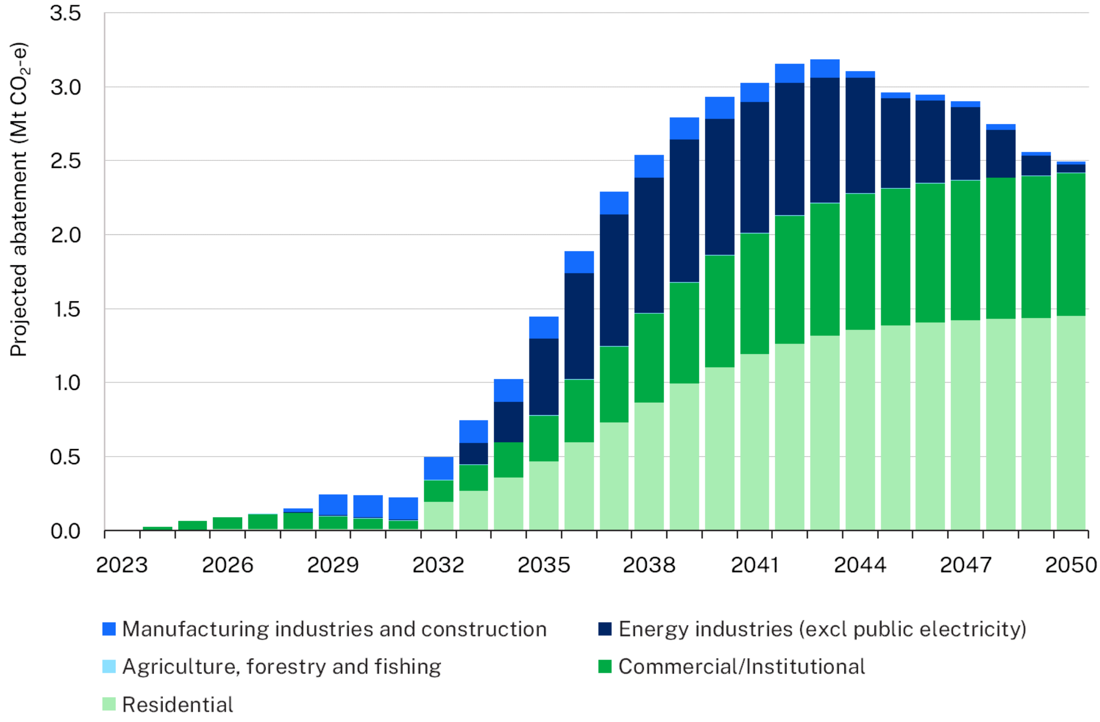

Figure 11 **Abatement projected to be achieved by programs and related policies for stationary energy subsectors**

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.

Summary of the emissions trends

Inventoried emissions (1990 to 2022) and emissions projections (2023 to 2050) for the NSW transport sector are shown in Figure 12 for business-as-usual (BAU) and Figure 13 for current policy.

Historical growth in transport emissions is driven by population increase, increased vehicle ownership, a shift from small passenger vehicles to sports utility vehicles and growth in light commercial vehicles (utes). 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 approximately 90% of transport sector emissions, with light-duty vehicles accounting for greater than 60% and the remaining 26% due to heavy-duty vehicles (mainly trucks). Domestic aviation, railways, waterborne navigation contribute approximately 3–4% each.

Figure 12 shows the short-term trend in emissions under BAU is characterised by a very steep post-COVID recovery from 2022 to 2023, particularly in light-duty vehicles and aviation. The sharp decline evident from 2021 to 2022 and the sharp recovery in 2023 is reflected in the fuel statistics for road transport. Following the increase to 2023, emissions from the sector decline slowly under BAU to 2030. The longer-term decrease is most evident in light-duty vehicles, reducing from 17.6 Mt CO_2-e in 2023 to 7.0 Mt CO_2-e in 2050, due to the increasing uptake of electric vehicles. There is a more modest reduction in heavy-duty vehicles under BAU, with emissions increasing from aviation. There is no decline in freight and aviation emissions into the 2030s, with only a modest reduction by 2050.

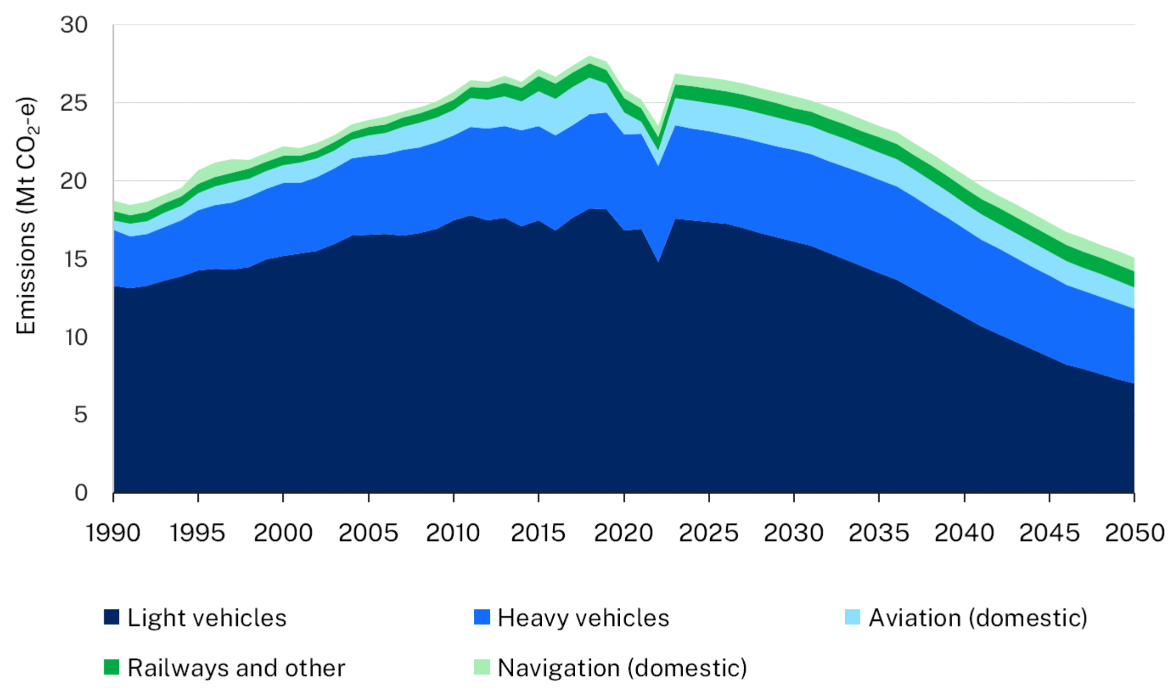

Figure 12 **Transport emissions by subsector showing inventory estimates (1990 to 2022) and BAU emissions projections (2023 to 2050)**

Figure 13 shows the increased emission reductions under current policy, mainly in road transport (light-duty and heavy-duty vehicles) as the fleet turns over and the share of EVs and zero emission buses and trucks in the stock increases. An increase in EV uptake is modelled under the EV Strategy and emission reductions in heavy-duty vehicles is supported by various NSW Government programs and policy (Hydrogen Strategy, Net Zero Freight, Zero Emissions Buses transition plan). A proportion of funding under future stages of the Net Zero Plan is also assumed to be allocated policies that increase abatement in heavy-duty vehicles.

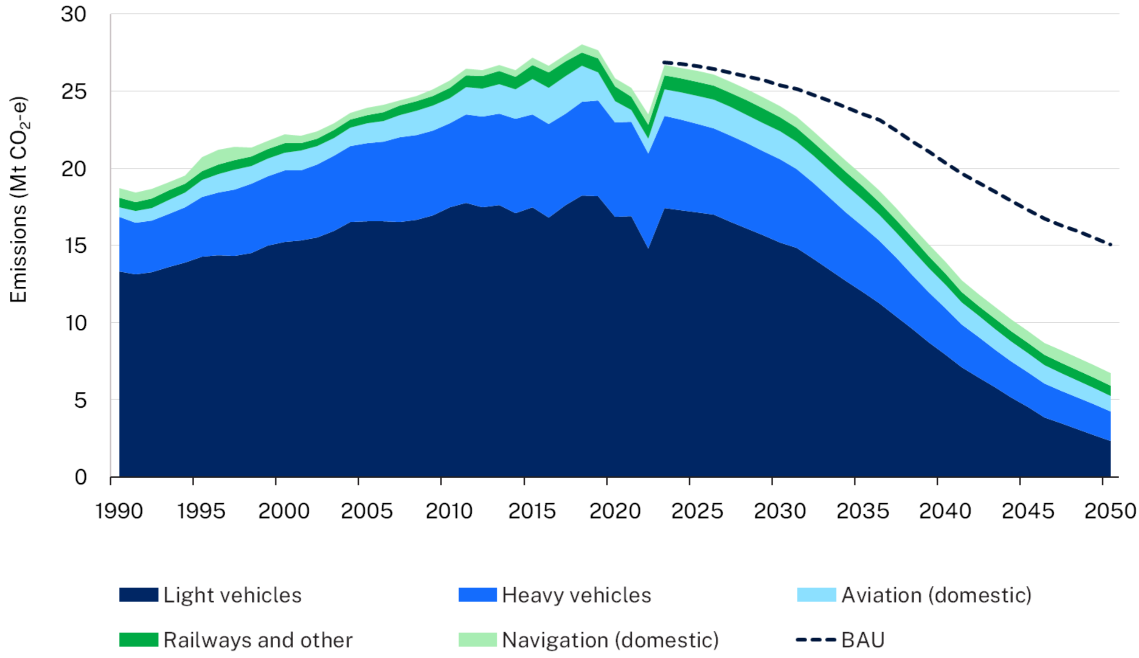

Figure 13 **Transport emissions by subsector showing inventory estimates (1990 to 2022) and current policy emissions projections (2023 to 2050)**

Methodology and assumptions

Road transport

The NSW Department of Climate Change, Energy, the Environment and Water's (the department) fleet and emissions models were used to project emissions from light and heavy-duty vehicles using a state-aggregated modelling approach, shown in Figure 14 and summarised as follows:

- the fleet model projects the future fleet by estimating fleet growth, vehicle sales and vehicle attrition from a base year of NSW registration data
- the emissions model estimates the fleet aggregate emission factors (grams of emission per kilometre – g/km)
- Transport for NSW (TfNSW) strategic transport models (Strategic Transport Model, Freight Movement Model, Regional Transport Model and Regional Freight Model) are used for future vehicle kilometres travelled (VKT) projections for light and heavy-duty vehicles. The fleet model can also estimate VKT, using the historical actual annual average VKT per vehicle type, size and age class, and the projected number of vehicles within each type, size and age class
- total emissions are calculated by multiplying VKT by vehicle type and fuel type by the emission factor.

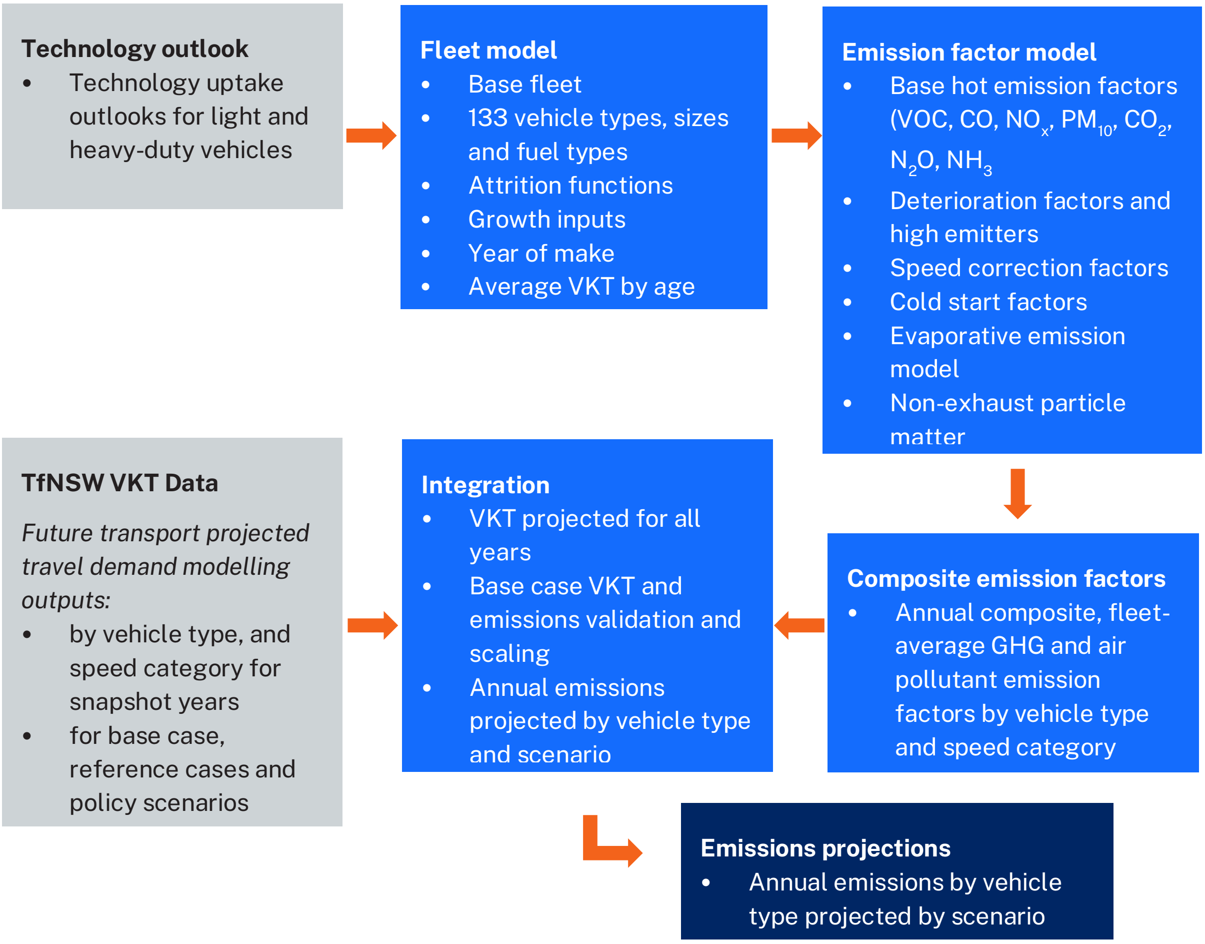

Figure 14 Fleet and emissions modelling applied for base case road transport projections

Fleet and emissions modelling

The NSW fleet and emissions models are based on models developed for NSW EPA air emissions inventories for the Greater Metropolitan Region (EPA 2012, 2019). These models were extended to all of NSW 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 (for example, 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 2024 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 2024. The growth in passenger vehicle and light commercial vehicle numbers was apportioned into fuel types and the fleet model size categories based on detailed Federal Chamber of Automotive

Industries (FCAI) 'VFACTS' sales data (FCAI 2024) supplemented by TfNSW data on new registrations.

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.

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 2024 from the base year of 2012 by applying the actual growth from the registration records, resulting in 2024 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.

Assumptions for electric vehicle uptake for light-duty vehicles in NSW

The *NSW Electric Vehicle Strategy* (NSW Government 2021) aims to ensure more than 50% of new car sales are EVs by 2031. Current actions under the strategy include rebates for EV buyers, fleet incentives for business and councils, and investment in EV charging infrastructure. The EV strategy is currently being reviewed, with a refocus on building a world-class EV charging network.

Modelling of a base case and a policy case for uptake rates of battery electric vehicles (BEVs) and plugin hybrid EVs were originally modelled by Veitch Lister Consulting for the strategy. These projected EV uptake rates have been compared to and updated based on the latest VFACTS sales data to June 2024. The BEV sales curve to date is then trended back to the original modelled EV uptake curve, reaching ~50% of sales by 2031. 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 to 2024 (FCAI 2024).

Assumptions for zero or low emission heavy vehicle uptake in NSW

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). 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.

Fleet average emission factors

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.

Emission factors are derived from:

- the Australian *National in-service emissions study* (DEWHA 2009) study for petrol vehicle emissions up to Australian Design Rules (ADR)79/01 (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.

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.

Vehicle Kilometres Travelled

NSW fleet-aggregate emission factors (grams of CO_2-e per km) are applied to VKT projections from transport modelling by TfNSW to project future emissions.

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.

The VKT projections accounts 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.

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.

Motorcycle emissions

Motorcycle emissions were projected based on national emissions projections multiplied by the ratio of NSW emissions to national emissions for each sector for the latest GHG inventory year (2022), with 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 23.

Table 23 Data referenced for projection of aviation emissions

Dataset	Description	Source
NSW population	NSW population projections based on common planning assumptions to 2060–61	DPHI, 2024
Bureau of Infrastructure and Transport Research Economics airport traffic data	Domestic revenue passenger numbers by airport (1985–2024)	BITRE 2024
Australian Petroleum Statistics	Sale of domestic and international aviation fuel in NSW (2010–11 to 2022–23)	Cth DCCEEW 2024f
Australian Energy Statistics	Australian Energy Update 2024	Cth DCCEEW 2024d
NSW States and Territories Greenhouse Gas Inventory	NSW domestic aviation emissions (1990–2022)	Cth DCCEEW 2024a
National Greenhouse and Energy Reporting	Kilolitre (kL) of fuel combusted in NSW and emissions for commercial aviation	Confidential data provided by the Clean Energy Regulator

Dataset	Description	Source
Scheme facility-level reporting data		

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 States and Territories 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 to 2023.

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 2024 domestic passenger numbers in New South Wales only marginally down on pre-COVID-19 levels (calculated based on outbound domestic passenger movements in NSW airports; BITRE 2024). The trend of increasing passenger movements is also recovering, with movements in FY 2024 returning to 3.5 movements per population.

Previous projections updates 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 6% 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 2025, based on the assumption that corporate travellers comprise 12% of total passenger numbers (PwC n.d.). These assumptions will be reviewed in future updates, as the actual COVID recovery shown in Figure 15 indicates that this reduction may not be reflected in the actual passenger movements.

In summary, future passenger numbers for New South Wales are projected out to 2050 based on the historical linear trend in growth with an ongoing reduction of 25% in business travel assumed.

The resultant trend is shown in Figure 15.

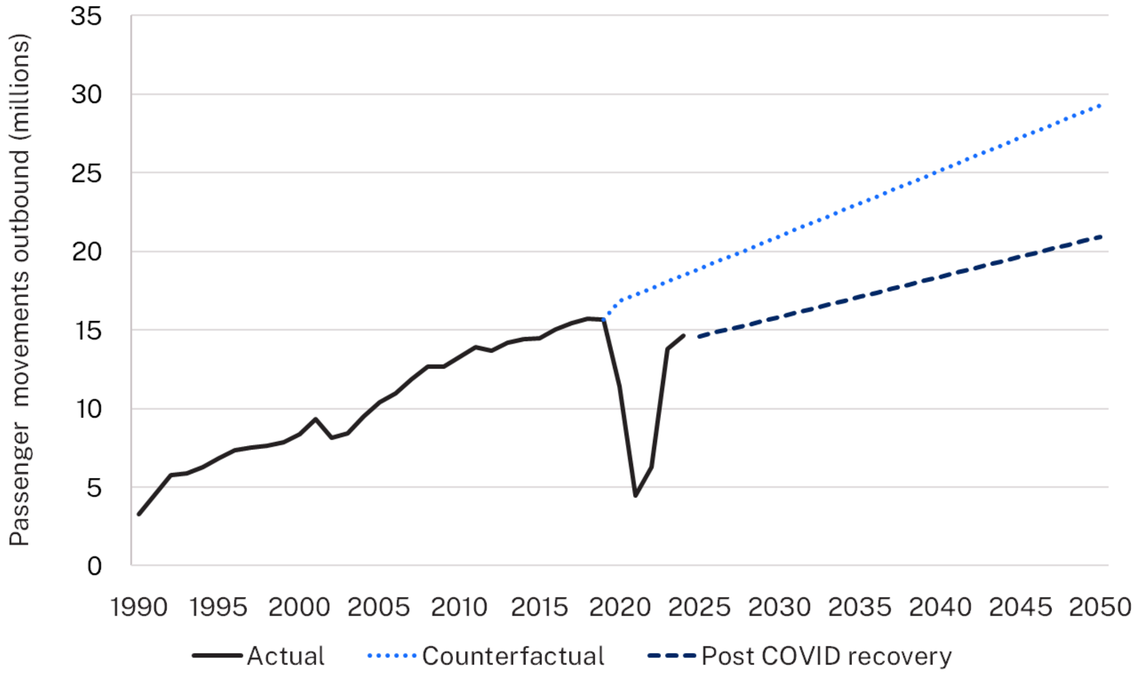

Figure 15 **Historical (1990 to 2024) and projected revenue passenger numbers (outbound) for New South Wales (2025 to 2050)**

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 43 million in 2050 (down from the previously projected 56 million in our 2023 projections). The reduction is due to the inclusion of the most recent COVID recovery years in the linear forecasts. 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), and 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 (that is, 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 to 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 16.

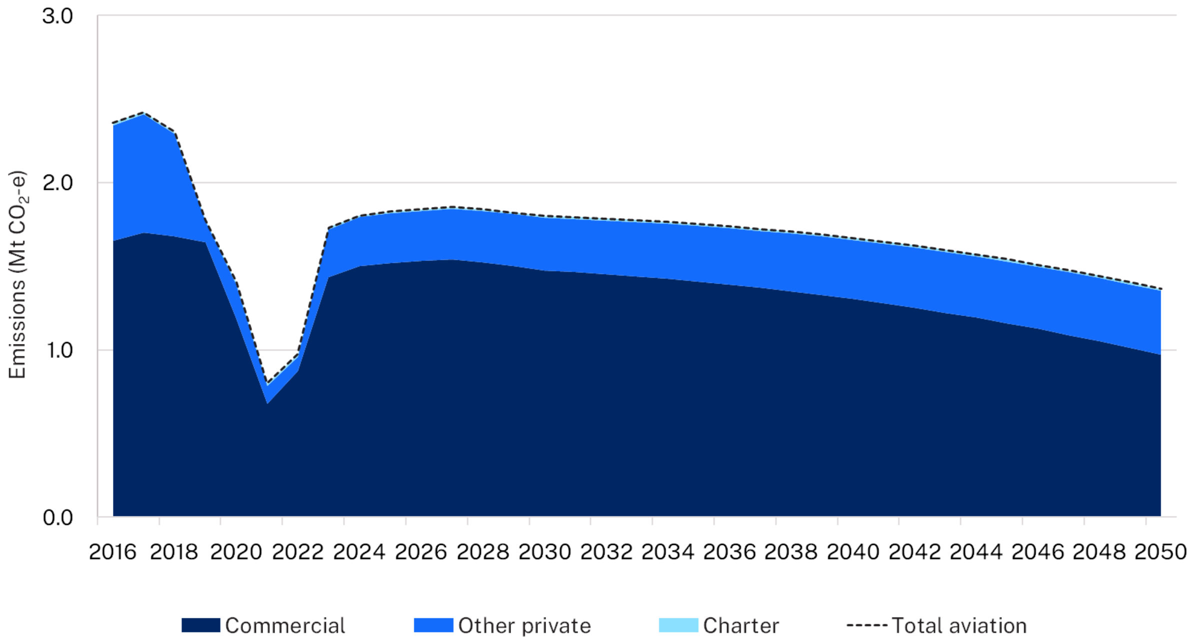

Figure 16 **Emission estimates for subcategories within the aviation subsector (2016 to 2050)**

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 24.

Table 24 **Data referenced for projection of railway emissions**

Data reference	Description	Source
NSW population	NSW population projections based on common planning assumptions to 2060–61	DPHI 2024
Australian Energy Statistics	Annual energy consumption in NSW for rail transport	Cth DCCEEW 2024d
Bureau of Infrastructure and	Kilometres travelled	BITRE 2021

Data reference	Description	Source
Transport Research Economics rail statistics		
Australian Rail Track Corporation and TfNSW – rail network data	Gross tonne kilometres (GTK)	NSW rail network data provided by the Australian Rail Track Corporation 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 (2011–2022)	Cth DCCEEW 2024a
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 to 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 to 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 (gross tonne kilometres (GTK)) and the historical fuel efficiency (L per GKT) for each commodity (derived from historical data 2016 to 2018). Fuel efficiency improvements for freight are also considered within the BAU 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 its 2020 *Climate strategy and action plan* (Aurizon 2020)
- Pacific National has committed to 50 new C44 Evolution locomotives in its fleet between 2021 and 2026, resulting in 9% less emissions than existing National Rail (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 25.

Table 25 Data referenced for projection of navigation emissions

Data reference	Description	Source
NSW population	NSW population projections based on common planning assumptions to 2060–61	DPHI 2024
Australian Energy Statistics	Annual fuel consumption in NSW for domestic (coastal) water transport	Cth DCCEEW 2024d
Bureau of Infrastructure and Transport Research Economics statistics	Port based maritime activity	BITRE 2022b
	Australian aggregate freight forecasts	BITRE 2019
NGERS 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 STGGI	NSW domestic navigation emissions (2011–2022)	Cth DCCEEW 2024a
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 to 20% fuel oil, ~35 to 40% diesel and 40 to 50% auto-gasoline (based on AES data from 2016 to 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 17. The emissions estimates for ferries incorporate the phased replacement of all diesel-powered craft with modern green energy alternatives by 2035.

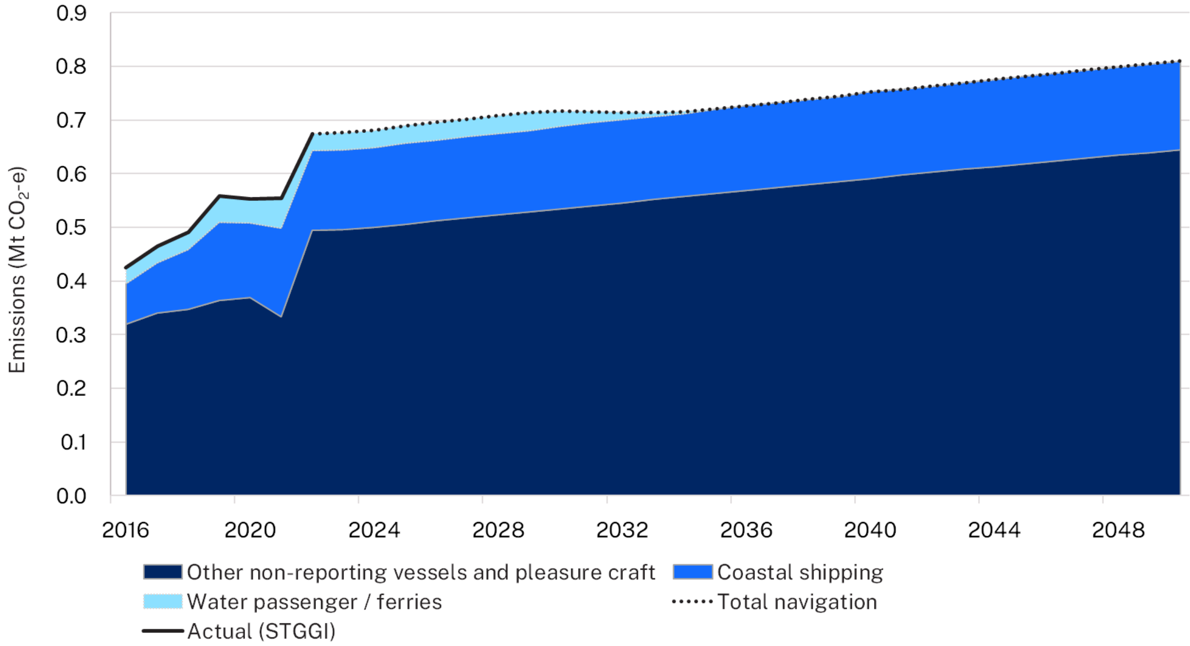

Figure 17 **Emission estimates for subcategories in the domestic waterborne navigation subsector**

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' chapter).

Activity data

Data used in the projection of NSW pipeline transport emissions are listed in Table 26.

Table 26 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	DPHI 2024
Australian Energy Statistics	Annual fuel consumption in NSW for 'Other transport, services and storage'	Cth DCCEEW 2024d
NGERS facility-level reports	NSW emissions for pipelines and other transport	Confidential data provided by the Clean Energy Regulator
NSW STGGI	NSW pipeline emissions (2011–2022)	Cth DCCEEW 2022a

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. They include:

- 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 27.

Table 27 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 2024d
NGERS facility-level reports	kL of fuel combusted in NSW, emissions by type	Confidential data provided by the Clean Energy Regulator
NSW STGGI	NSW emissions for off-road vehicles (2011–2021)	Cth DCCEEW 2024a

Projections approach

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

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

Transport emissions in the latest modelling are projected to be 1.4 Mt CO_2-e higher in 2030 and 3.4 Mt CO_2-e higher in 2035, compared to the previous projections update. The higher projected emissions across the transport sector are mostly a result of less abatement modelled for the heavy vehicle sector. Further details on the assumptions are presented in subsequent sections.

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 as follow:

- accelerated uptake 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
- funded action under future stages of the Net Zero Plan.

The NSW Electric Vehicle Strategy, as originally designed, aims to ensure more than 50% of new car sales are EVs by 2031. Actions under the strategy include rebates for EV buyers, fleet incentives for business and councils, and investment in EV charging infrastructure. The EV strategy is being redesigned, with a revised focus on building a world-class EV charging network. A base case and a policy case for BEVs and plugin hybrid EVs were modelled by Veitch Lister Consulting for the Electric Vehicle Strategy. The previously modelled EV uptake rates were compared against sales to date (to June 2024). For some vehicle categories (small passenger cars, large light commercial vehicles) the actual sales of EVs are 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. 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 modelling also assumes an accelerated uptake to reach 100% of sales by 2041, consistent with CSIRO modelling that informs the Australian Energy Market Operator (AEMO) Integrated System Plan (ISP).

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. Consistent with the strategy, the fleet is modelled to transition to 100% zero emissions buses in Greater Sydney by 2036, in outer metropolitan regions by 2040 and in regional NSW by 2047.

The *NSW Hydrogen Strategy* (DPIE 2021f) sets out policies to drive decarbonisation in hard to abate sectors, including transport. Abatement for freight transport under the hydrogen strategy is updated based on forecast hydrogen production for the NSW Hydrogen Hubs, with some uptake for hydrogen fuel cells for larger trucks also 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-modal 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 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).

Emissions reductions were also forecast for actions under future stages of the Net Zero Plan, in heavy-duty road, rail and aviation transport subsectors. The integrated abatement that is projected to be achieved under current policy is shown in Figure 18.

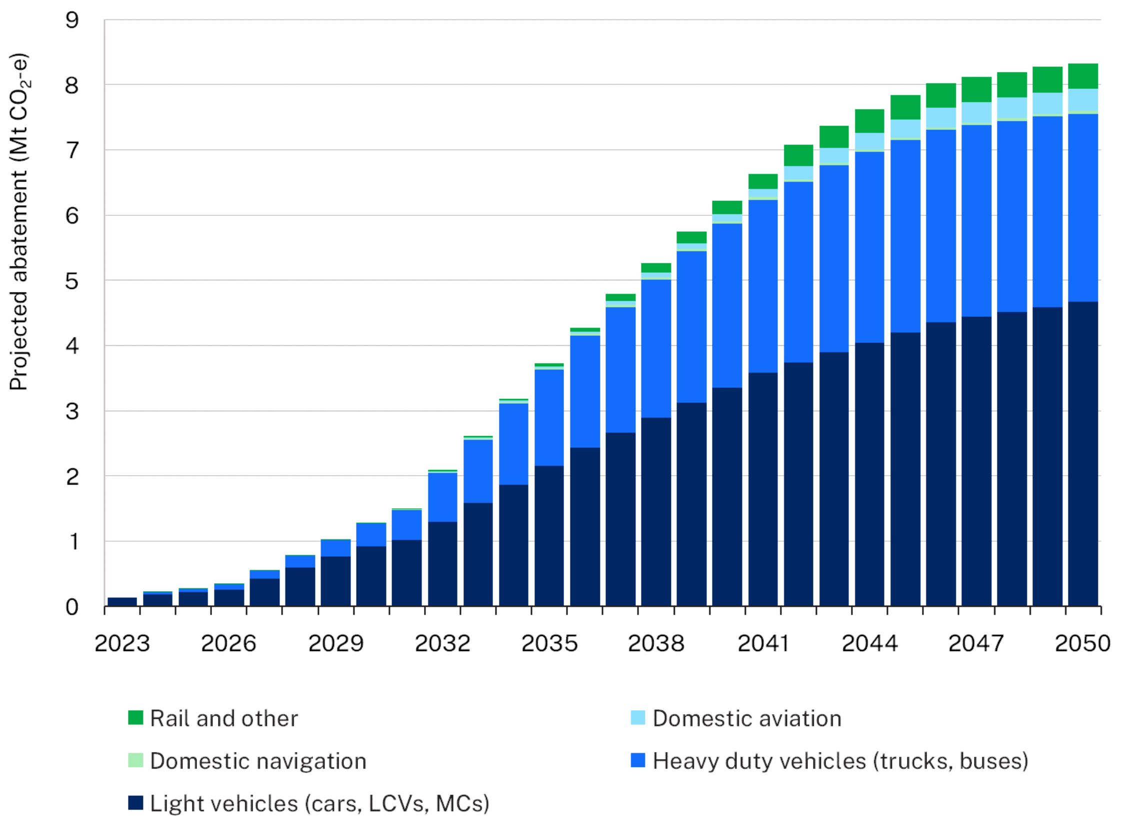

Figure 18 **Abatement of transport emissions projected to be achieved by Net Zero Plan stage 1 programs and related policies (2023 to 2050)**

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

Inventoried emissions (1990 to 2022) and projected emissions (2023 to 2050) for the NSW fugitive emissions sector by subsector are shown in Figure 19 for business as usual (BAU) and Figure 20 for current policy scenarios.

Emissions from underground coal mines are the primary source of fugitive emissions, representing the largest contributor despite fluctuations, with an average share of 78% from 1990 to 2022. Between 1990 and 2022, fugitive emissions decreased by 14.3 Mt CO_2-e, from 24.9 Mt CO_2-e to 10.6 Mt CO_2-e, a 57% reduction. Emissions from this sector decreased from 19.8 Mt CO_2-e in 2005 to 10.6 Mt CO_2-e in 2022. This decrease is primarily attributed to closure of underground coal mines.

As shown in Figure 19, under BAU assumptions, fugitive emissions are projected to increase from 11.2 Mt CO_2-e in 2023 to 15.4 Mt CO_2-e by 2027, primarily due to increasing coal production in the short term. Emissions are then expected to decline by 53.2% (8.2 Mt CO_2-e) between 2027 and 2042, reaching 7.2 Mt CO_2-e. By 2050 all coal mines are projected to close, bringing emissions from the sector down to 1.8 Mt CO_2-e (arising from decommissioned mines).

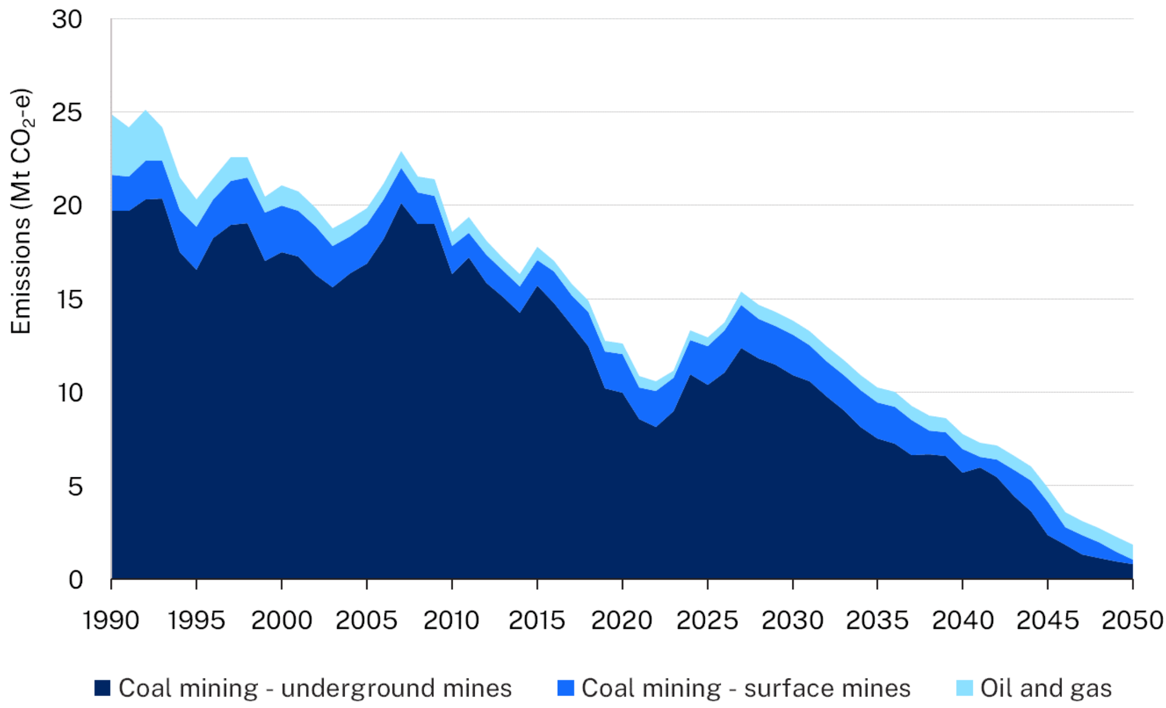

Figure 19 **Fugitive emissions by subsector showing inventory estimates (1990 to 2022) and BAU emissions projections (2023 to 2050)**

Figure 20 shows that the most significant emission reductions under the current policy scenario are expected from underground coal mining, which remains the dominant subsector. Conversely, surface coal mining and the oil and gas subsectors contribute a relatively smaller portion, with emissions of 1.9 Mt CO_2-e and 0.5 Mt CO_2-e in 2022, accounting for 18.2% and 5.1% of total fugitive emissions, respectively.

By 2030, combined emissions from surface coal mining and the oil and gas subsectors are projected to decline to 2.6 Mt CO_2-e, followed by a further reduction to 1.8 Mt CO_2-e in 2040, before nearly reaching net zero at 0.98 Mt CO_2-e by 2050.

Under the current policy, overall fugitive emissions are projected to decline gradually, reducing to 13.2 Mt CO_2-e in 2030, 7.6 Mt CO_2-e in 2035 and 1.8 Mt CO_2-e in 2050, underscoring the impact of ongoing mitigation efforts across all subsectors.

Abatement in this sector is projected to come from either programmatic funding, such as the Net Zero Industry and Innovation Program (NZIIP) or leveraged by the Australian Government's Safeguard Mechanism reforms and Environment Protection Authority's (EPA) climate change policy and action plan (CCPAP). Action under future stages of the Net Zero Plan is also assumed to abate the emissions in this sector after 2030.

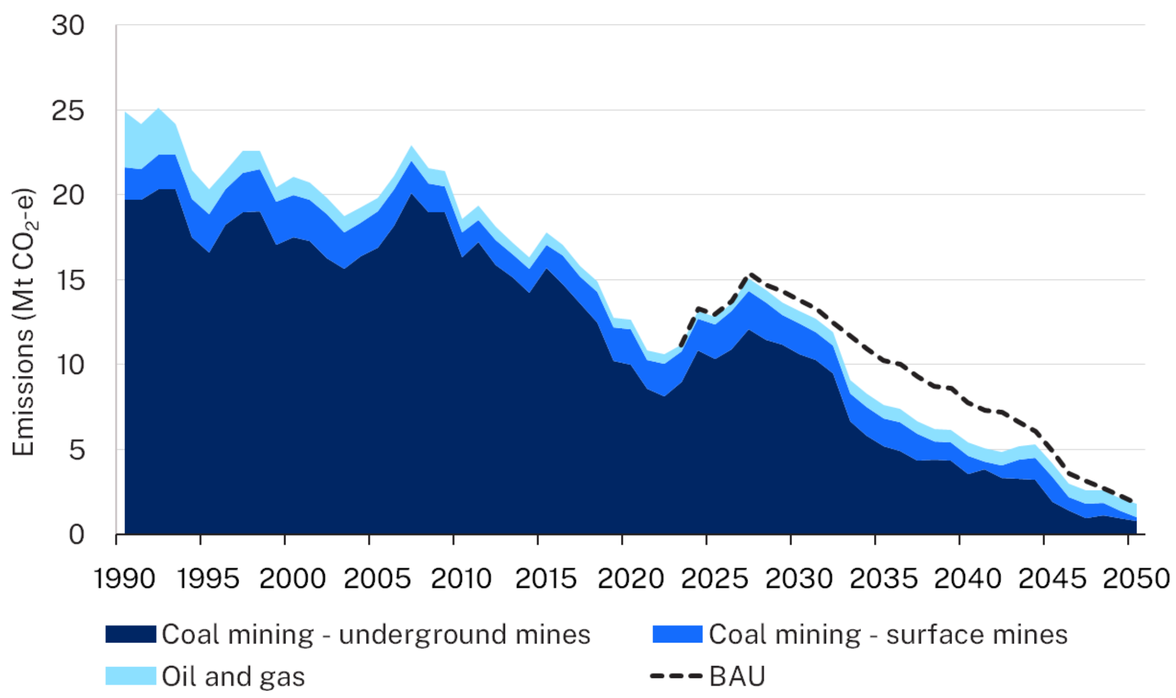

Figure 20 **Fugitive emissions by subsector showing inventory estimates (1990–2022) and current policy emissions projections (2023–2050)**

Methodology and assumptions

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

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 which are developed 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 impact statements that accompany mine extension proposals, have also been used where such information was more up to date.

Data on fugitive emissions from the gas sector in New South Wales is also primarily sourced from NGERS facility emissions. This includes all major gas transmission and distribution networks, storage facilities, and gas production and processing developments.

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 forecasts and mine-specific emission intensity factors based on the latest reported emissions.

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.

For the 2024 projections update, future ROM coal production forecasts were developed for 3 scenarios by the NSW Resources (Department of Primary Industries and Regional Development) (November 2024). The ROM coal production forecast scenarios are:

- Scenario 1 – production forecasts for all currently approved coal mine operations only
- Scenario 2 – Scenario 1 plus production forecasts for all coal mine modification and state significant development (SSD) applications that are currently under assessment with the Department of Planning, Housing and Infrastructure (DPHI)
- Scenario 3 – Scenario 2 plus production forecasts for all coal mine modification and SSD proposals for which scoping reports have been submitted to the DPHI.

To allow enough time for emissions projections to be developed, the cut-off date for information to be included in all scenarios was 15 November 2024. For existing operational mines under all 3 scenarios, the first 3 years of coal production was informed by the 3-year Forward Program as advised by NSW Resources.

For each scenario, future emissions are calculated for each mine by multiplying the latest fugitive emission factor by the forecasted ROM coal production; this assumes continuous extraction of coal with no changes in the gassiness (that is, changes in gas content and composition) of the seams being mined. This is assumed as data on changes in gas properties as mining progresses are not available and are kept confidential by coal mine operators.

For scenarios 2 and 3, ROM coal production forecasts and emissions reported in application documents for coal mine modifications and SSDs were considered the most recent available data, and therefore used in preference to the NSW Resources production forecasts.

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.

Mount Pleasant was the only open-cut coal mine to use method 1 to report fugitive emissions to NGERS in 2022–23. Fugitive emissions projections for Mount Pleasant were thus based on emissions reported in its optimisation plan, which received final approval by the Australian Government in September 2024.

In general, fugitive emissions data for open-cut mines are checked for the NGERS method used. If NGERS method 1 is used, advice is sought from the Australian Department of Climate Change, Energy, the Environment and Water (Cth DCCEEW) on the best approach and alternative emission factors are used.

Decommissioned coal mines

Decommissioned mine emissions are projected using a model based on 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, 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 the NSW Resources Group
- 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 in the Southern Coalfield 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} .

Emissions from decommissioned mines were also included under the 3 scenarios discussed in the previous section.

Inclusions for the 2024 projections

Under Scenario 1, emissions projections for all currently approved coal mine operations were developed. As of 15 November 2024, the following modifications and SSDs were included in addition to Scenario 1 under:

Scenario 2

- Chain Valley Consolidation SSD
- Hunter Valley Operations North Continuation SSD
- Hunter Valley Operations South Continuation SSD
- Mount Arthur Modification 2
- Moolarben OC3 SSD
- Newstan SSD
- Tahmoor South Modification 3
- Ulan MOD 6

Scenario 3

- Angus Place West SSD

- Appin Modification 4
- Appin Modification 6
- Bloomfield Modification 5
- Boggabri Modification 10
- Clarence Modification 8
- Dartbrook Modification 8
- Maules Creek Continuation SSD
- Metropolitan Modification 4
- Russel Vale Modification 2
- Rix's Creek North Continuation SSD
- Ulan Modification 8
- Wilpinjong Modification 3

Emissions estimated for the original Hunter Valley Operations North and South Continuation SSD were included in the 2024 projections update instead of Hunter Valley Operations North Modification 8, since limited information was available for Modification 8 at the time of preparation of the projections.

Russell Vale Colliery announced an early closure with coal scheduled to cease in February 2024; hence emissions from decommissioning are included from 2024–25 onwards.

Emissions projections for Mount Pleasant Operations are based on the optimisation project which received final approval from the Australian Government in September 2024 and are included under all scenarios. Modification 7 for Mount Pleasant Operations was not considered for the 2024 projections update.

Emissions projections from decommissioning at 23 underground mines were included in the 2024 update across the 3 scenarios. The number of mines entering decommissioning is projected to increase as operations reach approved closure dates.

The BAU scope 1 emissions projections for the coal mining sector are presented in Figure 21 for the 3 scenarios developed for the 2024 update. Note that this projection includes stationary energy emissions produced by the sector. Overall, the emissions trends for the 3 scenarios are similar, decreasing steadily to residual values of between 0.8 Mt CO_2-e for Scenario 1 and 1.2 Mt CO_2-e for Scenario 3 by 2050. As discussed, emissions projections for modifications and SSDs listed above were included in scenarios 2 and 3 for the 2024 emissions projections update. Scenario 2, for fugitive and stationary energy emissions, was selected as the most suitable scenario to represent the sector’s emissions at the state level, along with the accompanying current policy projection for Scenario 2.

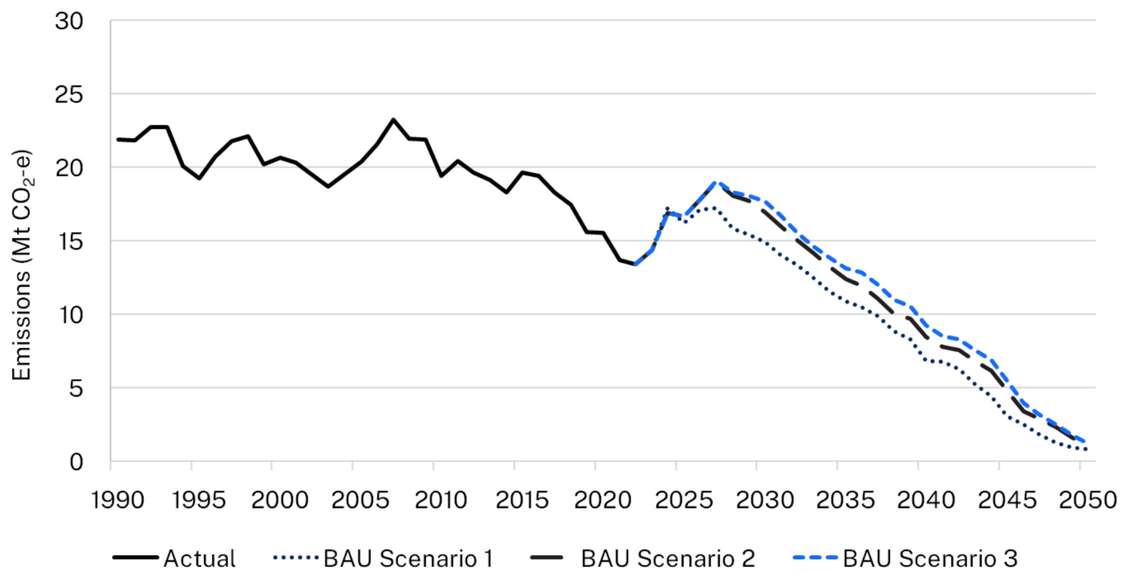

Figure 21 **Scope 1 emissions for coal mining showing inventory estimates (1990–2022) and BAU emissions projections for 3 scenarios developed for the 2024 update**

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 CH_4 and CO_2 from venting and flaring from gas production and processing.

Gas fugitive emissions projections for transmission and distribution pipelines and storage facilities were based on NGERS data. This includes emissions from venting, flaring and fugitive leaks. The NGERS data for each type of emission over the period FY 2016 to FY 2023 were averaged and held constant out to 2050. The averages were taken as there is insufficient information on these facilities to perform a more detailed calculation of future projections.

The projections also included the 2 production developments, Port Kembla Energy Terminal (PKET) and the Narrabri Gas Project (NGP), which were assumed to commence operations in FY 2026 and FY 2028, respectively. Data for these 2 projects were obtained from environmental impact statements (EIS), available in the public domain (DPE 2022d). Both EIS emissions datasets were based on maximum gas delivery scenarios. EIS emissions were modelled based on 100 petajoules per annum (PJ p.a.) delivery for PKET and 73 PJ p.a. delivery for NGP.

Note, in the case of the NGP, the BAU scenario assumes the project uses imported grid electricity (Option 2 in the EIS). The projections account for a decarbonising electricity grid.

An external supply/demand analysis was performed using the Australian Energy Market Operator's (AEMO) *2021 Gas statement of opportunities* (GSOO) central case (Scenario 1) (AEMO 2021). This provided a forecast of the PJ of future liquefied natural gas (LNG) import and processing requirements at PKET and production from NGP out to 2040. This data was used to then scale down the emissions from PKET and NGP.

The supply/demand analysis indicated an increase from 30 to 100 PJ p.a. delivery over a 15-year period at PKET and a maximum delivery of 40–50 PJ p.a. from NGP in most years.

Given the current status of the PKET and NGP projects, the production and emissions projections are unchanged until more accurate data can be obtained.

Note that the AEMO GSOO 2021 projections extend only to 2040. The emissions projections in this work hold the 2040 emissions constant out to 2050.

Changes in emissions since last year's projection update

Up to about 2040 coal and gas fugitive emissions are projected to be similar to the previous update (Figure 22); thereafter emissions are projected to be slightly lower than the previous update through to 2050. This is due to the refined ROM coal production forecasts developed for the scenarios in consultation with NSW Resources. The approach taken in 2024 means that ROM coal production forecasts do not include potential resources that could be mined but are not currently approved or applying for approval under a modification or SSD, as was the case using the NSW Resources 'most likely' production forecasts in 2022 and 2023.

Gas sector emissions are largely unchanged from the previous update, as the NGP and PKGT projects are still under development.

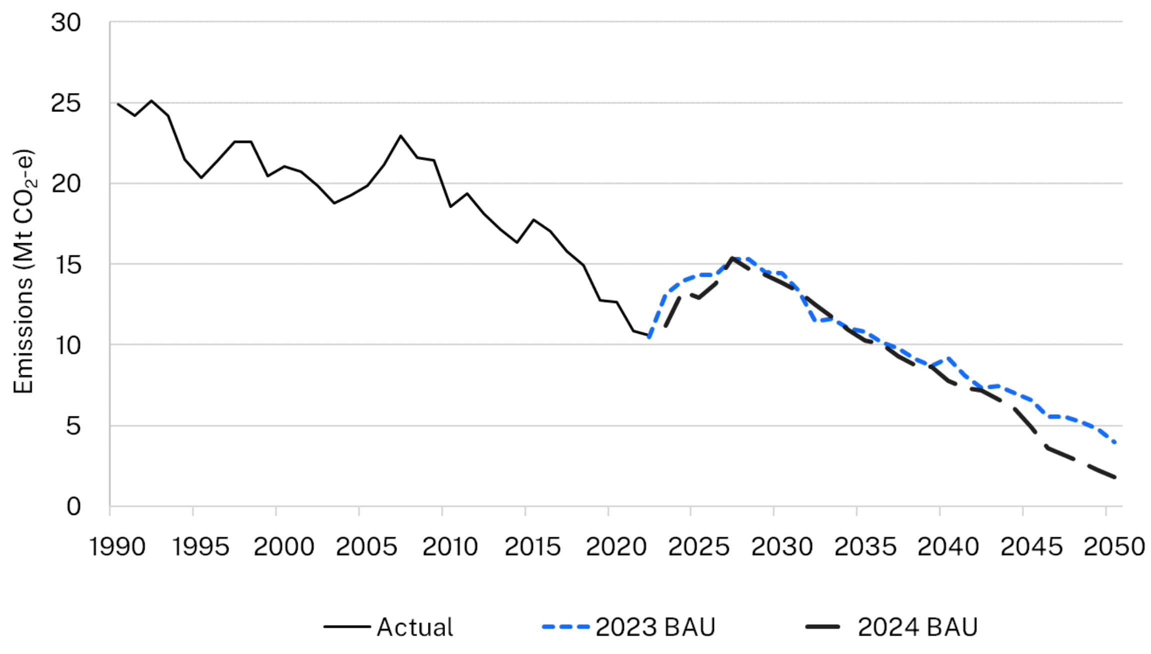

Figure 22 **Comparison of 2023 and updated 2024 BAU fugitive emissions projections**

The key changes in current policy projections for 2024 compared to 2023 were the inclusion of goaf sealing at some gassy underground mines and an increase in the upper limit of emissions from open-cut mines considered for potential pre-drainage from 100 kilotonnes (kt) CO_2-e to 200 kt CO_2-e. No changes were made to the timeframes for 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, with the latter starting in 2033. This is assumed to happen under NZIIP incentives or Safeguard Mechanism requirements.

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. The program has undergone review in 2024 and the projections has been updated to reflect the revised abatement projections for the program, including interaction with the Safeguard Mechanism.

The Coal Innovation NSW (CINSW) funded South32 (now owned by GM3) 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 regenerative thermal oxidiser (RTO) with a safe ducting system at the Appin Mine. Project outcomes include full-scale RTO operations demonstrated with improved safety and commercial viability.

The 2024 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 for Scenario 2, the remaining mine life and findings from technical feasibility studies, emissions reductions of between 1.4 and 2.6 Mt CO_2-e per year were estimated to be achievable from this sector between 2033 and 2043. 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. 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. The integrated abatement that is projected to be achieved is shown in Figure 23.

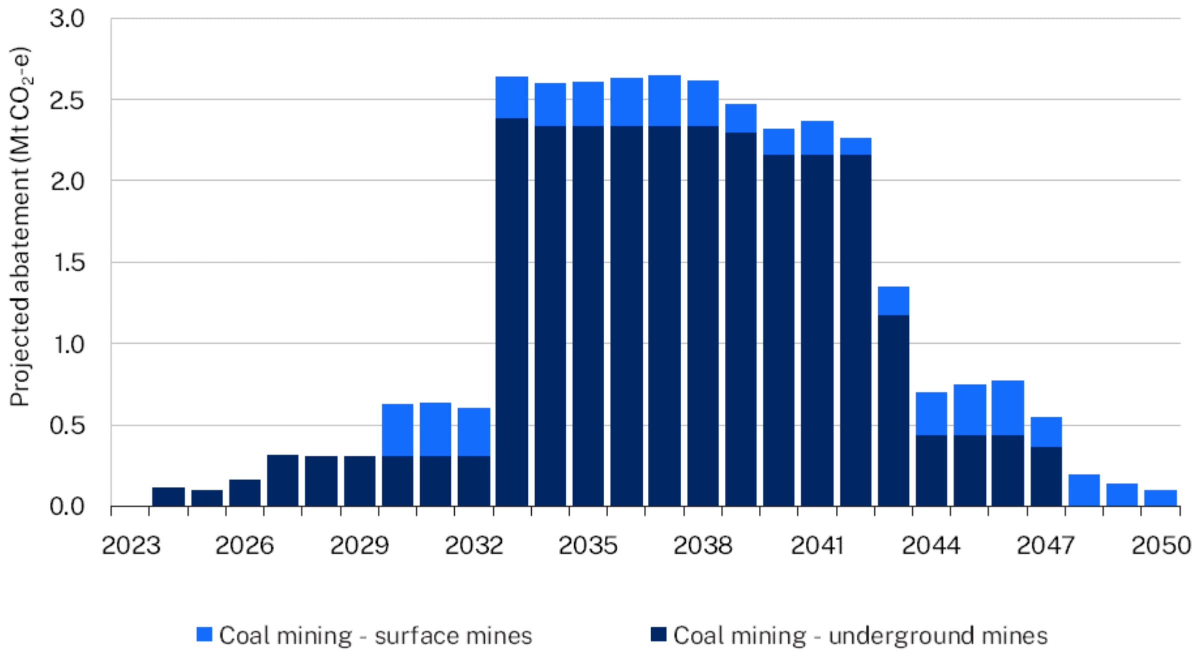

Figure 23 **Abatement of fugitive emissions from underground coal mining projected to be achieved by Net Zero Plan programs and related policies (2023 to 2050)**

Coal mining emissions and the Safeguard Mechanism

Of the 35 facilities in New South Wales covered by the Safeguard Mechanism in 2022–23, 26 were coal mines. For the 2024 emissions projections update, preliminary Safeguard declining baselines were developed for the coal sector, which includes all 26 Safeguard facilities.

These declining baselines were calculated using the facility-specific emissions intensity values (CER 2025) for each individual facility as provided by the Clean Energy Regulator, and the scope 1 BAU projected emissions for each facility (Scenario 2). The declining baselines were calculated according to the Safeguard method (Australian Government 2024) using decline rates of 4.9% from 2023–24 to 2029–30 and 3.285% from 2030–31 to 2049–50.

Figure 24 shows the results of this preliminary analysis. Between the years 2023–24 and 2034–35 the projected total scope 1 BAU emissions for the coal sector are slightly higher than the total scope 1 BAU emissions for Safeguard facilities only. This difference is attributed to a small number of facilities that do not meet Safeguard thresholds and small quantities of emissions from historically decommissioned mines.

As discussed in the previous section, several plausible opportunities for onsite abatement were identified across the coal sector under the current policy scenario. Figure 24 shows the scope 1 emissions projections under the currently policy scenario, and includes fugitive and stationary energy abatement opportunities.

From around 2032–33 onwards plausible onsite abatement could make a significant contribution to the coal sector meeting its obligations under the Safeguard Mechanism.

In 2030 the sector needs to reduce emissions by 6.9 Mt CO_2-e to meet its obligations, with only 0.6 Mt CO_2-e assumed as plausible onsite abatement. By 2035 a reduction of 5.3 Mt CO_2-e is required of which 3.1 Mt CO_2-e is assumed as plausible onsite abatement, and by 2050 a reduction of 0.3 Mt CO_2-e is required of which 0.1 Mt CO_2-e could be achieved through onsite abatement.

Should the coal sector meet its obligations under the Safeguard Mechanism in all future years going forward, the sector's emissions reduction trend will generally be consistent with its historical declining trend. The peak in the declining baseline in 2042–43 (Figure 24) reflects the closure of a gassy underground mine. Reported emissions during the decommissioning of underground coal mines are considered the baseline under the Safeguard Mechanism.

There is limited available data and information on onsite abatement that is currently being achieved at individual coal mines, and on abatement potential going forward, as well as how facilities will meet their Safeguard obligations. Further opportunities to improve the abatement estimates and assumptions will be sought.

Note that these preliminary findings are based on Scenario 2 which includes several modification and SSD applications awaiting determination with DPHI. If any development applications are unsuccessful this may reduce the preliminary figures presented above.

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, the Safeguard Mechanism 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 Appin coal mine
- consider the impact of new corporate commitments announced and potential changes to the Safeguard Mechanism on the emission intensity projections for coal and gas fugitives.

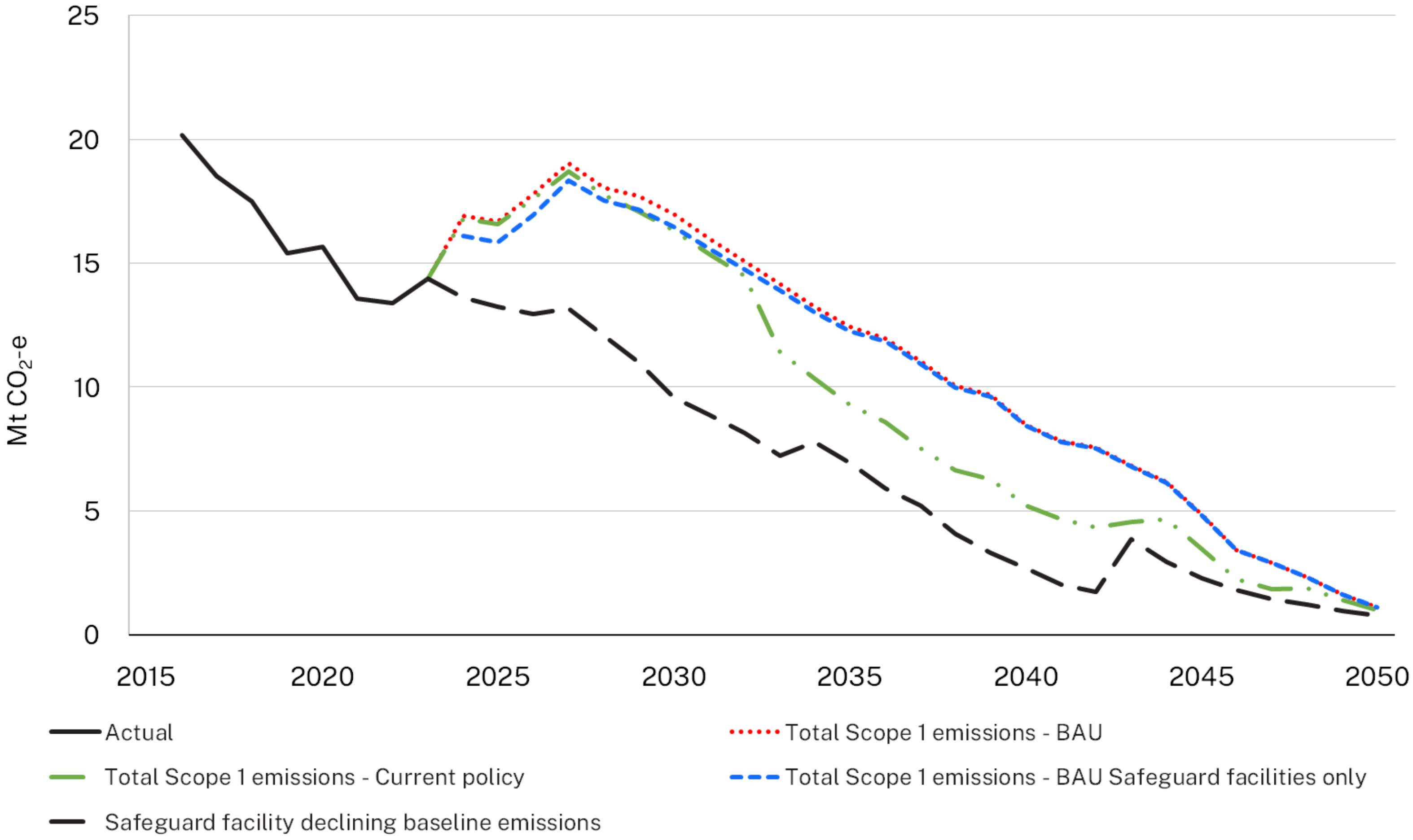

Figure 24 **Scope 1 emissions for coal mining showing inventory estimates (1990 to 2022), scope 1 BAU and current policy emissions projections, scope 1 emissions for Safeguard coal mines only, and the Safeguard declining baseline for the coal mining sector (2023 to 2050)**

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 (that is, hydrofluorocarbons [HFCs] used as refrigerants).

Summary of the emissions trends

Inventoried emissions (1990 to 2022) and emissions projections (2023 to 2050) for the NSW IPPU sector by subsector are shown in Figure 25 for a business-as-usual (BAU) scenario and Figure 26 for the current policy scenario.

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. The metal industry is the dominant subsector, accounting for 55% (7.2 Mt CO_2-e) of all IPPU emissions in 2022. The second-largest source is the use of halocarbon replacements for ozone-depleting substances (ODS), such as refrigerant gases in imported equipment, inventoried as 'product uses as ODS substitutes'. This subsector contributed 26% (3.5 Mt CO_2-e) in 2022. The mineral industry and chemicals/other subsectors follow, contributing 10% (1.3 Mt CO2-e) and 8% (1 Mt CO2-e) of total IPPU emissions, respectively.

Figure 25 shows that under the BAU scenario, IPPU emissions are projected to decrease from 12.5 Mt CO_2-e in 2023 to 11.5 Mt CO_2-e in 2030, 11.4 Mt CO_2-e by 2035 and 10.3 Mt CO_2-e by 2050. This decline is primarily driven by the phase-down of the import of HFCs, based on the Australian Government program to phase-down the import of goods containing halocarbons with high global warming potential (reductions in the product uses as ODS substitutes subsector).

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

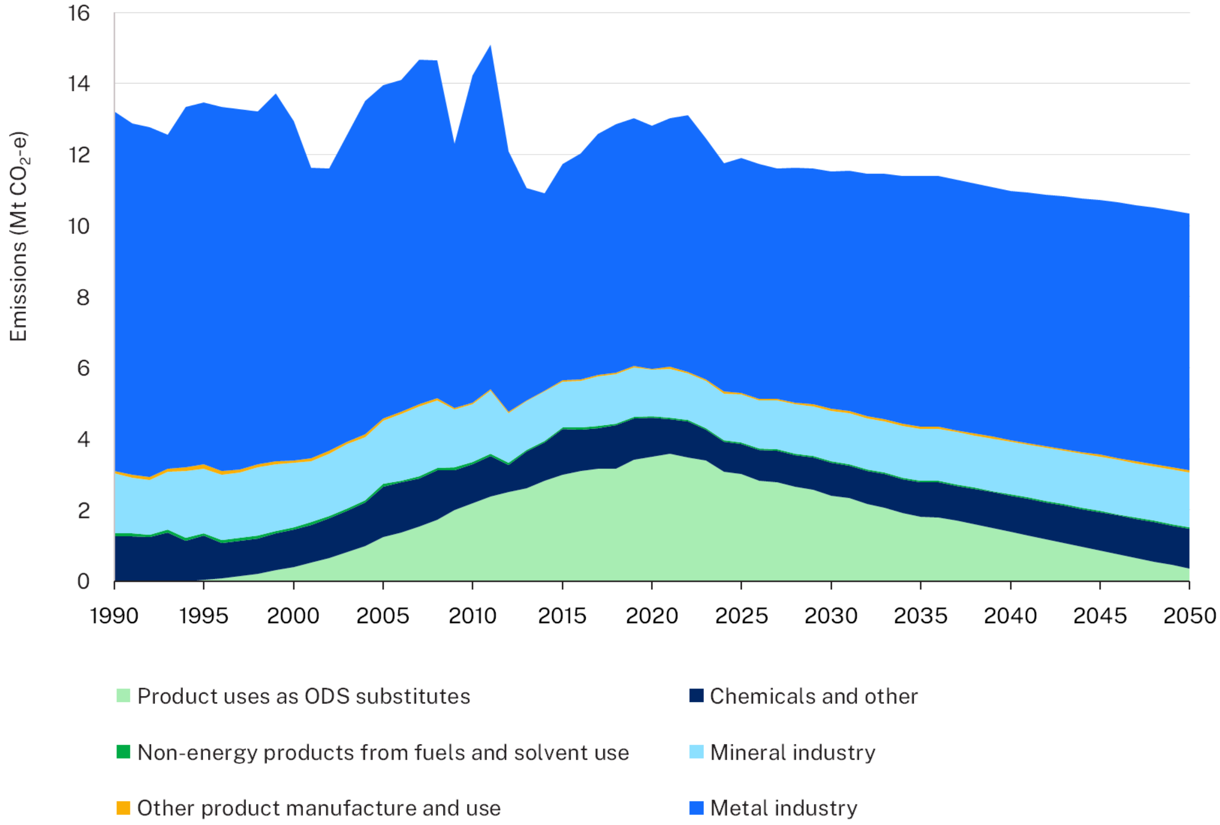

Figure 25 **Industrial processes and product use emissions by subsector showing inventory emissions (1990 to 2022) and BAU emissions projections (2023 to 2050)**

Figure 26 shows the emission trajectory under current policy, with additional reductions mainly in the metal industry. Under current policy, emissions reductions are projected to decline from 12.5 Mt CO_2-e in 2023 to 10.9 Mt CO_2-e in 2030, 10.0 Mt CO_2-e in 2035 and 3.8 Mt CO_2-e in 2050. Abatement in this sector is based on programmatic funding under the Net Zero Industry and Innovation Program (NZIIP) and the NSW Hydrogen Strategy, plus opportunities for onsite abatement leveraged by the Australian Government's Safeguard Mechanism reforms and the Environment Protection Authority's (EPA) climate change policy and action plan (CCPAP). Funded action under future stages of the Net Zero Plan is also modelled for this sector.

The large step changes in abatement seen in 2040 and 2045 reflect assumptions made for implementation of green steel at BlueScope Port Kembla and, to a lesser extent, green ammonia at Orica Kooragang Island. This potential onsite abatement could occur through a combination of program-based government support or through regulations (that is, Safeguard Mechanism reform obligations or EPA CCPAP), but is acknowledged as highly uncertain at this point in time and requiring transformative changes from 2040.

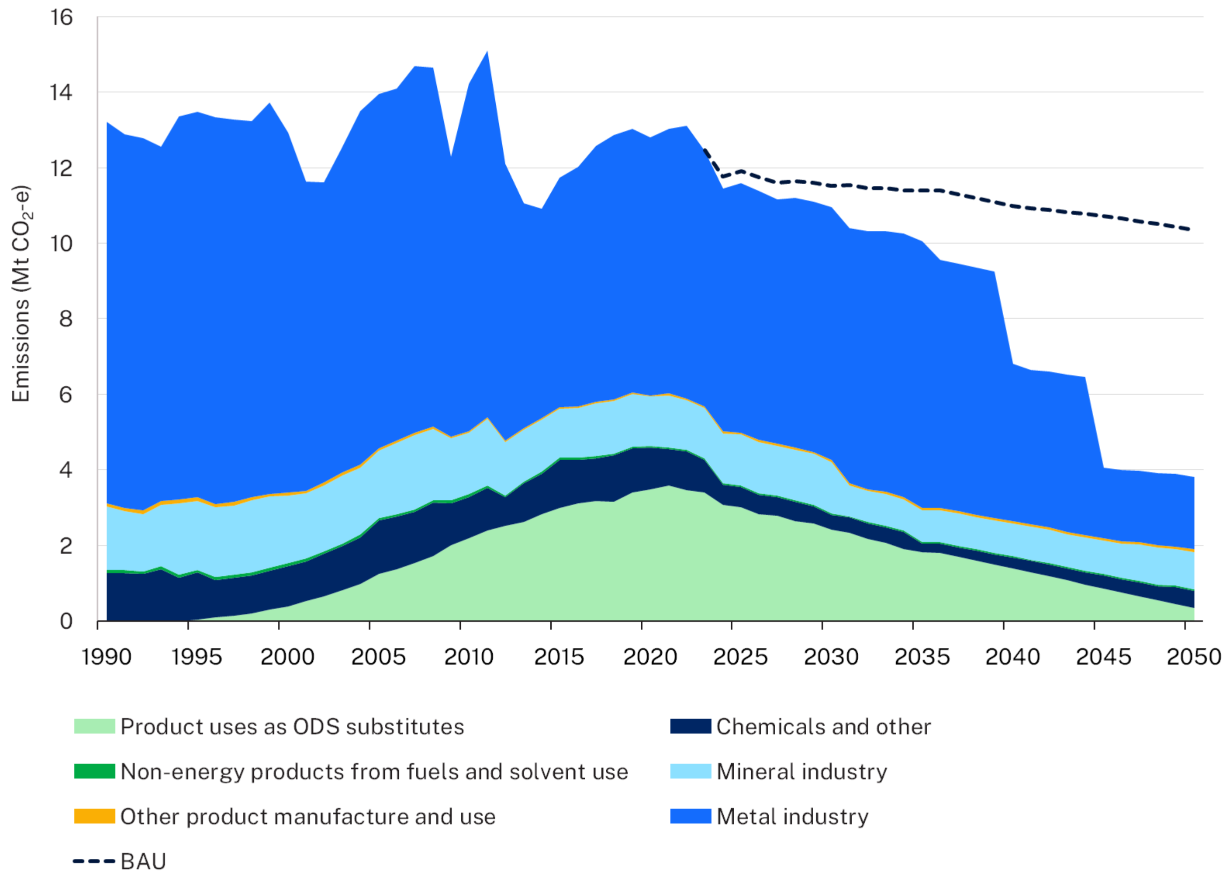

Figure 26 **NSW industrial processes and product use sector emissions as inventoried (1990 to 2022) and current policy projections ranges (2023 to 2050)**

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 adequate due to the availability of data. This uses either revenue projections or population projections, for example:

- revenue projections from IBISWorld (IBISWorld 2024), based on IBISWorld revenue growth rates
- population projections (DPE 2022g), where the emissions are calculated according to the formula:

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

where:

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

The following changes were made for these projections:

- forecasts for steel and aluminium production were updated with the 2024 Office of the Chief Economist *Resources and Energy Quarterly* (OCE REQ)
- commodity revenue projections were updated with 2024 IBISWorld data
- long-term forecasts for major commodities, including steel, aluminium and cement over the period 2030 to 2050 were improved using recent CSIRO data (CSIRO 2023)
- commodity forecasts were derived by an average extrapolation of CSIRO Rapid Decarbonisation (CRD) and CSIRO Stated Policies (CSP) scenarios (CSIRO 2023)
- in the iron and steel subsector, MolyCop Waratah (formerly Commonwealth Steel Waratah) is excluded from 2025 due to its announced closure in February 2024
- in the aluminium subsector, Tomago's abatement commitment was updated to include reduction of perfluorocarbons and a pilot trial for inert anode.

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 NGERS facility data for the sector.

Ammonia production

For ammonia production, 2 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 2023 to 0.385 Mt p.a. in 2070–71. Production is capped at 0.385 Mt p.a. from 2070–71 (Orica 2022a). Current greenhouse gas (GHG) emission intensities for 2023 are assumed to remain constant until 2050. Orica's commitments for onsite abatement are outlined in Table 28.

Table 28 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 Mineral Carbonation International (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 BAU or current policy abatement. Table 29 summarises green ammonia opportunities identified for the Orica Kooragang Island facility.

Table 29 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)	2026–2050	Total emissions reduction of 0.003–0.3 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 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 IBIS World 2024 revenue growth rates (IBISWorld 2024).
- 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 2024 to 2029, IBIS World 2024 forecast is used (Table 30). For 2030 to 2050, published information from Orica is used. This assumes that the additional nitric acid plant will commence in 2030, and production of nitric acid will grow linearly from 2031 to reach 0.605 Mt p.a. in 2070–71. The maximum capacity is 0.605 Mt p.a. (Orica 2022a).

Table 30 **Australian Government forecasts for chemical industry, percentage change in production (2024 to 2029)**

2024	2025	2026	2027	2028	2029	2030
–6.4%	–1.6%	5.2%	4.6%	2.3%	3.0%	1.2%

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

Note that:

- continued operation of the selective nitrous oxide (N_2O) catalyst abatement at Orica is already accounted for through lower emission intensities based on recent NGERS data
- the Kooragang Island Decarbonisation Project involving EnviNOx has also been implemented. In total, it delivers a 48% reduction in site emissions and is co-funded by the NSW Government.

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 2024 States and Territories Greenhouse Gas Inventory (STGGI) (Cth DCCEEW 2024a) for carbide processing was used as the basis for the calculation. The data is scaled by the annual percentage change in the NSW population (DPE 2022g) as per the Australian Government Department of Climate Change, Energy, the Environment and Water (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 February 2024. Scenarios considered included the OCE projection scenario and the CSIRO commodity production forecasts (CSIRO 2023). Transport for NSW (TfNSW) commodity demand forecasts (TfNSW 2022g) and Bloomberg New Energy Futures' *New energy outlook 2021* (BNEF NEO 2021) growth scenario (BNEF 2021a) are considered as boundary scenarios.

The OCE projection scenario (for 2024 to 2029) and the CSIRO commodity production forecasts (for 2030 to 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 boundary (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 2023 is assumed as a constant until 2050.

For 2024 to 2029, data from the OCE June 2024 REQ forecast (DISR 2024a) and March 2024 REQ forecast (DISR 2024b) (covering 2027 to 2029) are used to project iron and steel production in New South Wales, as shown in Table 31.

Table 31 Office of the Chief Economist forecasts for iron and steel percentage change in production (2024–2029)

2024	2025	2026	2027	2028	2029
–6.54%	4.15%	0.00%	–2.31%	2.42%	0.33%

From 2030 to 2050, a domestic growth scenario is assumed with new production expansion continuing. The steel production growth rates are derived from an average extrapolation of CSP and CRD scenarios in CSIRO (2023).

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 (that is, a pathway opportunity) (Table 32), however, this measure is not included in the BAU projections; rather it is considered a future pathway opportunity to address Safeguard Mechanism obligations.

Table 32 Green steel opportunities for Port Kembla Steelworks

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
Green steel – hydrogen direct reduced iron (DRI), DRI-melter basic oxygen furnace (BOF) or DRI-electric arc furnace (EAF))	2040–2050	2.4–4.7 Mt CO_2-e	BlueScope, in its 2021–22 Sustainability report (BlueScope 2022b), notes that it: • is installing and commissioning a 10-megawatt 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 DRI using green hydrogen, produced from renewable electricity

Aluminium and lead 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. For 2024 to 2029, a combination of data from OCE REQ June 2024 (DISR 2024a) and OCE REQ March 2024 (DISR 2024b) were used to forecast aluminium production in New South Wales, as shown in Table 33.

Table 33 Office of the Chief Economist forecasts for aluminium percentage change in production (2024 to 2029)

2024	2025	2026	2027	2028	2029
2.29%	–0.37%	0.00%	0.00%	0.00%	0.00%

From 2030 to 2050, a domestic growth scenario is assumed with new production expansion continuing. The aluminium production growth rates are derived from an average extrapolation of CSP and CRD scenarios in CSIRO's report *Pathways to Net Zero Emissions* (CSIRO 2023). 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 2023 is assumed as a constant until 2050.

Tomago's commitments for onsite abatement are outlined in Table 34.

Table 34 Abatement commitments for aluminium

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
Process improvement	2024–2050	Total reduction starts at 13,000 t CO_2-e in 2024 up to 26,000 t CO_2-e p.a.	Safeguard Mechanism website (CER 2020). Tomago Aluminium has several perfluorocarbon (PFC) emissions reduction trials underway and committed to installing an upgraded version of its pot control system in 2020 that has the potential to reduce PFC emissions in operations
Inert anode pilot trial	2035	Not public	Tomago Aluminium is likely to undertake inert anode pilot trial for Bake Oven Stacks, referred to in the NZIIP Transformative Industry Projects (TIP) study

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 Australian Bureau of Statistics (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 CSIRO forecast for cement production in Australia (CSIRO 2023) 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 1.6 Mt p.a. in 2050 (CSIRO 2023).

The current GHG emission intensity for cement clinker production at the Boral Berrima facility in 2023 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 35. The carbon capture, utilisation and storage project is expected to be delayed until 2035.

Table 35 Abatement commitments for cement clinker production

Abatement commitment	Estimated FY for implementation	Estimated scope 1 abatement	Details/funding
Clinker substitution and other process improvements	2024–2050	Reductions range from 3% in 2024 up to 14% by 2050	Corporate commitment
Carbon capture, utilisation and storage (pilot plant for mineral carbonation)	2035–2050	Total reduction up to 100,000 t CO_2-e p.a. in 2035 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 minerals

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 2023 is assumed as a constant until 2050.

The remaining 5 mineral subsectors are forecast based on the revenue growth rates given in Table 36, based on IBISWorld forecasts (IBISWorld 2024) to 2029. For NSW glass and soda ash production, the proxy production growth rates are tuned down (33% of IBISWorld growth rates), as major glass production growth in Australia is due to a new facility in Queensland, not New South Wales.

After 2029, 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 36 Revenue forecast for mineral product subsectors (2024–2029)

Produce subsector	2024	2025	2026	2027	2028	2029
Glass production	0.07%	3.20%	1.17%	1.47%	1.50%	1.47%
Magnesium production	–	–	–	–	–	–
Unspecified limestone and dolomite use	–	–	–	–	–	–
Soda ash use	0.07%	3.20%	1.17%	1.47%	1.50%	1.47%
Ceramics	–4.90%	0.70%	0.70%	1.90%	–0.30%	0.10%

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 2024a), 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 the average hydrochlorofluorocarbon (HCFC) imports for 2011 to 2013.

As detailed data on HFC and HCFC containing stock (for example, air conditioners and refrigerators) is not available for New South Wales, Cth DCCEEW's emissions projections from 2024 to 2035 were adopted, with an assumed linear trend in emissions for 2036 to 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 (2024a). Emissions are calculated using the relevant energy content and emission factors. For projections to 2050, emissions are adjusted for annual percentage changes in the 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 2022 as the base year and future emissions were calculated by adjusting for annual percentage changes in the NSW population (DPE 2022g).

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

The updated BAU emissions for IPPU are projected to be lower than the 2023 update (Figure 27), mainly due to lower commodity growth forecasts for the sector.

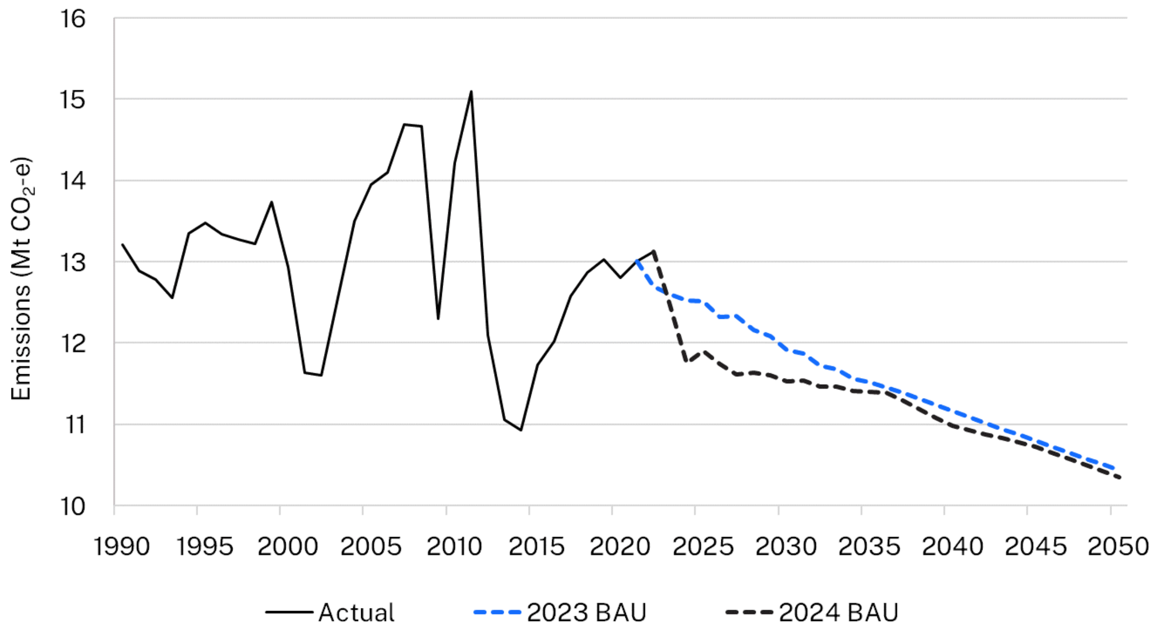

Figure 27 **Comparison of 2022 and updated 2023 BAU emissions projections for the industrial processes and product use sector**

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 (through green ammonia production). Current policy abatement for IPPU also includes the EnviNOx N_2O abatement project at the Orica Kooragang Island facility, which is supported by the NZIIP program.

Current policy abatement for IPPU also includes potential onsite abatement through the implementation of green steel at BlueScope Port Kembla and green ammonia at Orica Kooragang Island. As noted previously, this potential onsite abatement could occur through a combination of program-based government support or through regulations (that is, Safeguard Mechanism reform obligations or EPA CCPAP). It is acknowledged as highly uncertain at this point in time and requiring transformative changes from 2040.

The abatement projected under the current policy scenarios is shown in Figure 28. The large step changes in abatement reflect assumptions made for implementation of green steel at BlueScope Port Kembla and green ammonia at Orica Kooragang Island, with abatement of up to 2.4 Mt CO_2-e to 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.

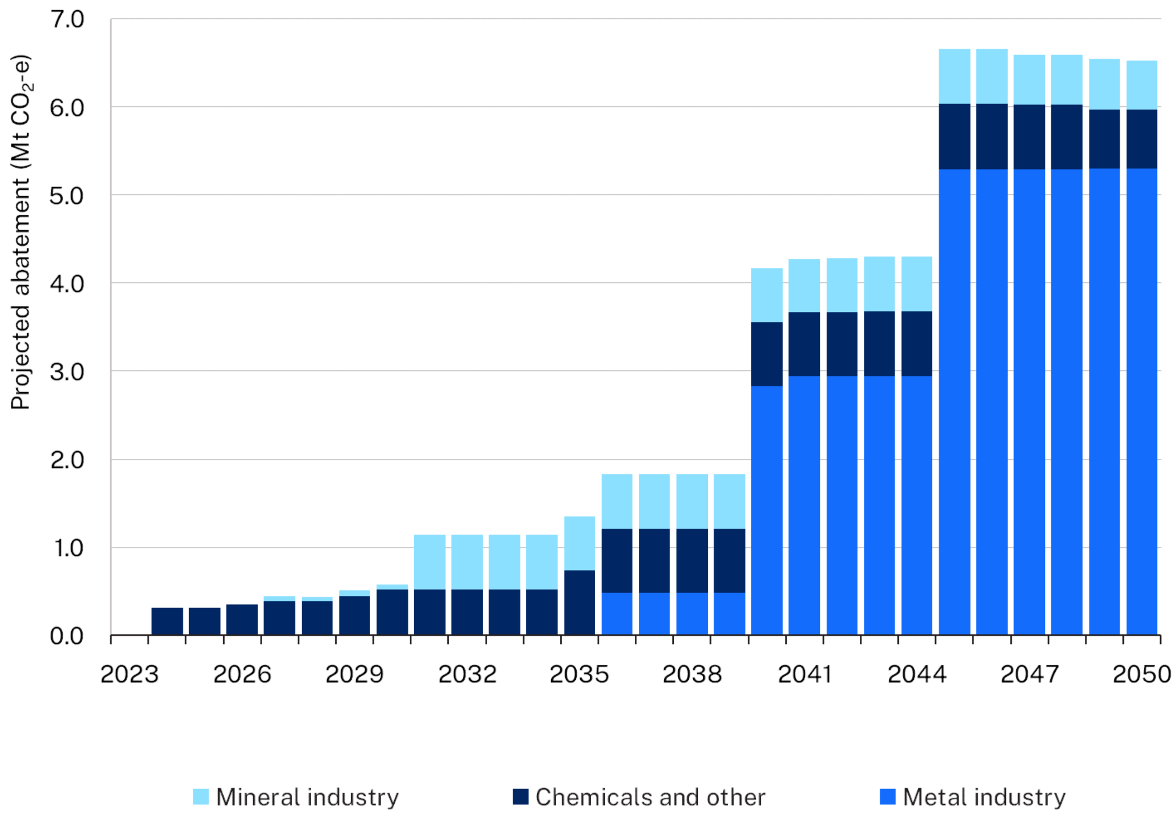

Figure 28 **Abatement of industrial processes and product use emissions projected to be achieved by Net Zero Plan and related policies (2023 to 2050)**

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. 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

Greenhouse gas (GHG) emissions from livestock and agriculture soils are the key contributors to agricultural emissions, driven by the processes of enteric fermentation, manure management and nitrification and denitrification.

Enteric fermentation is a digestive process in ruminants where microorganisms break down food in the animal's rumen, producing methane (CH_4) as a by-product. Enteric methane emissions are influenced by factors such as diet composition, feed quality, animal type, age and management practices.

Manure management releases methane and nitrous oxide. Methane (CH_4) emissions are produced during anaerobic decomposition of manure, particularly in wet or liquid storage systems such as lagoons. Nitrous oxide (N_2O) emissions occur from manure when nitrogen undergoes nitrification and denitrification processes, especially in soils or when manure is applied as fertiliser. The rate and volume of emissions from manure depend on storage and treatment methods, temperature, moisture content and oxygen availability.

Agriculture soils are estimated to contribute 15 to 30% of the anthropogenic N_2O at the global scale (Bouwman 1990; Tubiello et al. 2013) with approximately 70% associated with microbial nitrification and denitrification (Braker and Conrad 2011; Syakila and Kroeze 2011).

Nitrification, the oxidation of ammonium (NH_4) to nitrate (NO_3), is regarded as the main source of N_2O emissions under aerobic conditions in soil (Braker and Conrad 2011; Butterbach-Bahl et al. 2013; Firestone and Davidson 1989). In contrast, denitrification, the reduction of NO_3 to dinitrogen (N_2) in absence of oxygen (O_2), is the main source of N_2O emissions under soil anaerobic conditions (Butterbach-Bahl et al. 2013; Firestone and Davidson 1989). N_2O emissions from nitrification and denitrification are controlled by the availability of ammonia (NH_4), NO_3, soil soluble organic carbon, and the environmental factors such as soil moisture, temperature and pH.

It is noted that anthropogenic management activities that result in changes to soil carbon and carbon stock in croplands and grasslands are accounted for in the land use, land-use change and forestry (LULUCF) sector.

Summary of the emissions trends

Inventoried emissions (1990 to 2022) and emissions projections (2023 to 2050) for the NSW agriculture sector are shown in Figure 29 (business as usual (BAU)) and Figure 30 (current policy).

Emissions from agriculture vary from year to year due to the influence of climate (particularly drought) on livestock numbers and crop productivity. Modelled future emissions include this climatic influence on emissions (detailed description of the revised modelling approach is presented below).

Inventoried emissions (1990 to 2022) show a declining trend, with a reduction in emissions of 7% since 2005. There is a noticeable decline in emissions from 2018 to 2020, corresponding to a period of drought across New South Wales, most noticeable in crops and livestock.

Cattle and sheep production accounted for 80% of agriculture emissions in 2022, with 70% of this due to enteric fermentation, and are projected to remain the major contributors to agricultural emissions.

Figure 29 shows that under BAU, emissions are projected to decline slightly. Emissions are projected to decline from 18.7 Mt CO_2-e in 2023 to 16.6 Mt CO_2-e in 2030, increasing slightly to 16.8 Mt CO_2-e in 2035, before declining to 15.1 Mt CO_2-e in 2050. Livestock remains the primary contributor, with sheep and pasture-fed cattle contributing 48.7% and 36.9%, respectively, while crop production is responsible for about 7%. Fertiliser application and direct emissions from urea and lime contributes 3.8% and 2.2% of annual emissions from agriculture sector.

The emission reductions under current policy are observed as shown in Figure 30. The reductions are mainly in the grazing beef (herd management), dairy (feed additives) and grain fed beef (feed additives) subsectors. Abatement is modelled for the Primary Industries Productivity and Abatement Program (PIPAP), as well as action under future stages of the Net Zero Plan. Under current policy, modest addition emissions reductions are projected to 16.5 Mt CO_2-e in 2030, 15.6 Mt CO_2-e in 2035 and 13.4 Mt CO_2-e in 2050.

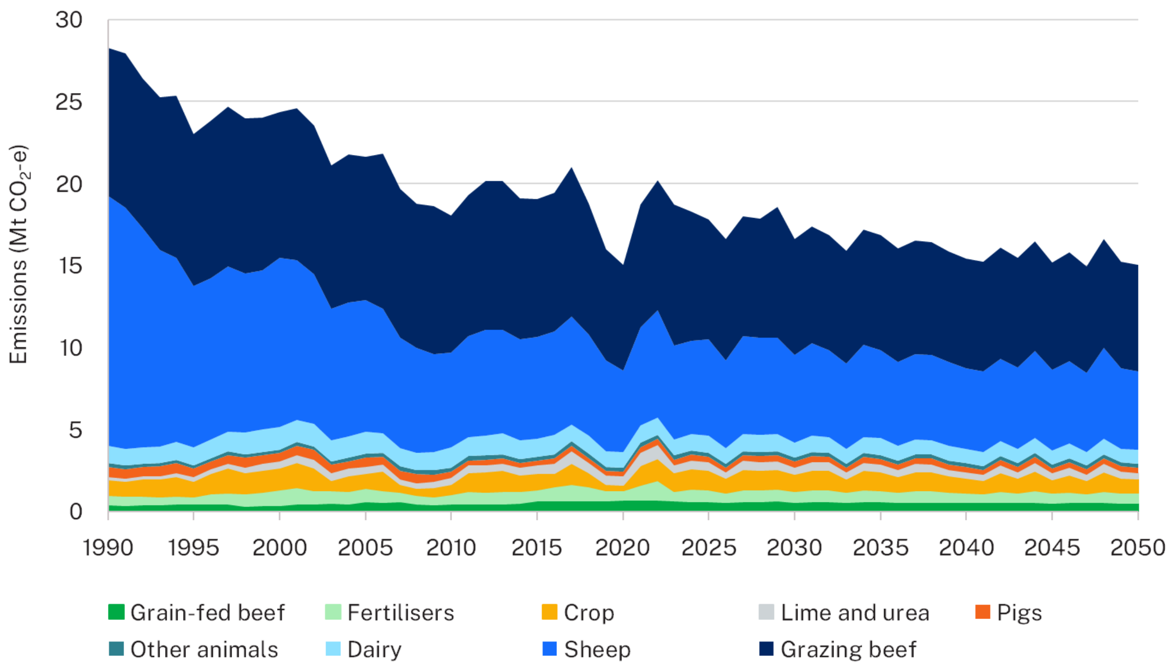

Figure 29 **Agriculture emissions by commodity showing inventory emissions (1990 to 2022) and BAU emissions projections (2023 to 2050)**

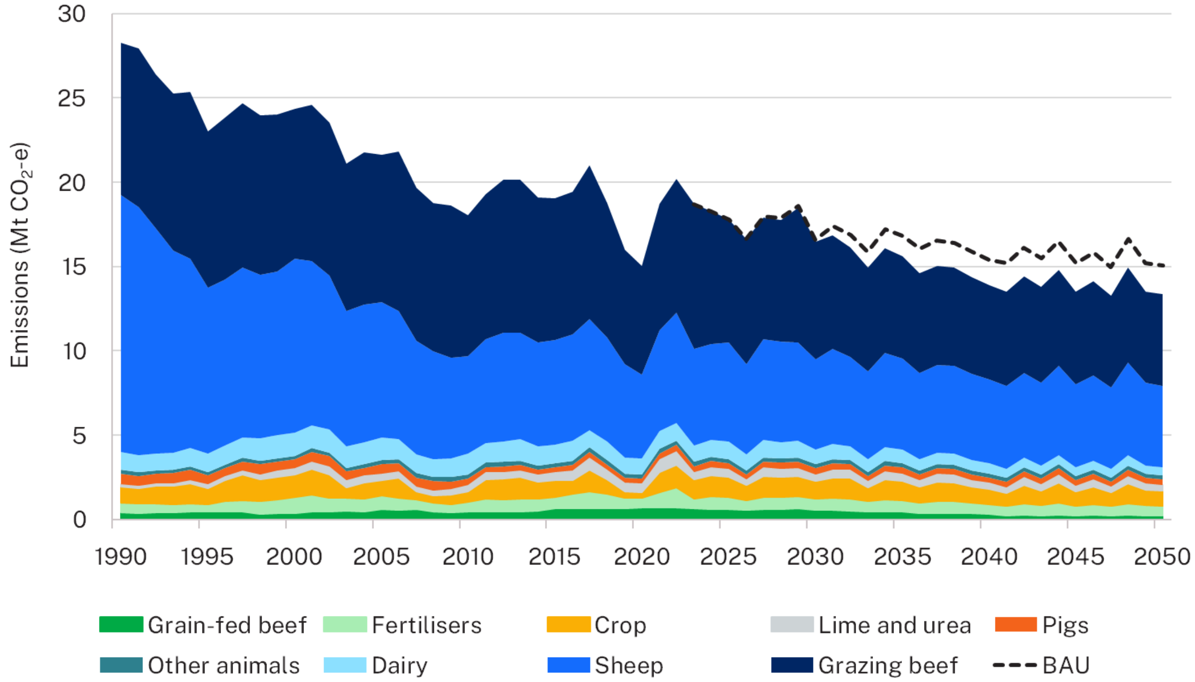

Figure 30 **NSW agriculture sector emissions as inventoried (1990 to 2022) and current policy projections (2023 to 2050)**

Methodology and assumptions

Emissions projections in previous updates (2023 and 2022) were based on activity data/growth factors derived from commodity outlooks. Emission intensities were calculated for each subsector, using States and Territories Greenhouse Gas Inventory (STGGI) emissions data divided by the corresponding activity for the commodity/subsector in that year, and applied to the activity outlook data to project future emissions. The key limitation to this approach is that outlook data is only available for short- and medium-term periods and aggregated at a national level. Post-outlook years, a linear regression to the long-term average (2010 to 2021) was applied.

A refined modelling approach is used for the 2024 update, using machine learning algorithms. Given the complexity and non-linearity of the relationships between factors driving agricultural emissions, machine learning (ML) approaches have gained significant traction in recent years. ML algorithms can handle hierarchical and nonlinear interactions between variables, outperforming conventional regression models in many cases (Belayneh et al. 2014; Guzman et al. 2018). Machine learning algorithms, including Random Forest (RF), Support Vector Machines (SVM) and neural networks are particularly well-suited for analysing diverse and complex inputs.

The RF machine learning algorithm is applied to quantify the relationships between the large-scale climate indices in New South Wales and the productivity of livestock and crops, and emissions from fertiliser and lime applications. RF is a decision tree-based ensemble machine learning approach, introduced by Breiman (2001) to improve regression accuracy. The RF model is trained by many classification and regression trees (CARTs) that are grown with a random subset of predictors. Many random trees are generated when the source data for the model is bootstrapped and, finally, the forest (group of random trees) of the CART is averaged. A more detailed explanation of the model is provided by Breiman (2001). The 'randomForest' package in the software R (Liaw and Wiener 2002; R Core Team 2020) is used for these projections.

Data inputs and approach

The key data inputs to the RF model are:

- historical long-term annual activity/productivity of key crops and livestock from 1990 to 2022 obtained from the Australia Bureau of Statistics (ABS 2024)
- historical GHG emissions emitted from crops, livestock, fertiliser and lime usage obtained from the 2022 STGGI
- historical annual climate variables, including maximum and minimum air temperature, rainfall and potential evapotranspiration (PET) obtained from the Bureau of Meteorology
- future climate variables from 2023 to 2050 obtained from NARCliM 2.0 under the SSP1-2.6 (low emissions) scenario (New South Wales and Australian Regional Climate Modelling Version 2.0).

The modelling approach for each subsector is shown in Table 37. The ML model is prioritised for the subsectors with the highest emissions, with a simplified linear regression model applied for the minor commodities and subsectors.

- For crops, we model the historical annual yield response to past climate and predict future yields based on future climate.
- For cattle and sheep, we model the historical livestock numbers response to annual carbon stock changes in grassland and past climate and predict future livestock numbers and annual carbon stock change under future climate conditions.
- Direct emissions from fertiliser and lime application in cropping systems is modelled based on the productivity of key crops in New South Wales, and fertiliser use on pasture is modelled in the same way as cattle and sheep.
- For poultry and swine, RF models were developed based on historical annual crop yield, predicting poultry and swine numbers based on future crop productivity. The limitation in this approach was noted during peer review, due to a significant proportion of imported feed (particular in the poultry industry). Refinements to the model are therefore planned for future updates.
- For smaller subsectors, we apply a simple regression to the long-term mean.

Emission intensities were held constant for the BAU projections except for intensive livestock, which were assumed to achieve a modest reduction of 10% by 2050 to reflect recent policy directions by major industry bodies, such as Meat & Livestock Australia, the National Farmers Federation, and Dairy Australia.

Table 37 **Modelling approaches for each subsector**

Sector	Subsector	Modelling approach
Crops	Wheat, cotton, sorghum, barley, rice, sugarcane, oilseeds, maize, oats, pulse and forage crops	$Y_i = f(Y_{i\_His}, Precipitation, Temperature, Evaporation)$
	Other cereals, etc.	Regression to the long-term (2001–22) mean
Livestock	Cattle-pasture, dairy cattle, sheep	$S_i = f(C_{Grassland}, Precipitation, Temperature, Evaporation)$
	Cattle feedlot, swine, poultry	$S_i = f(Y_{Crop-1_{j=i-N}}, Precipitation, Temperature, Evaporation)$
	Other livestock	Regression to the long-term (2001–22) mean
Fertiliser	Fertiliser applied in irrigated and non-irrigated crops (kt/year)	$F_i = f(Y_{crop\ (j-1\ -N)})$
	CO_2 emissions from applied urea and lime in NSW agricultural systems (kt CO_2/year)	$CO2_i = f(Y_{crop\ (j-1\ -N)})$
	Fertiliser applied in horticulture	$F_i = f(F_{i\_His}, Precipitation, Temperature, Evaporation)$
Pasture	Irrigated and non-irrigated pasture	$F_i = f(C_{Grassland}, Precipitation, Temperature, Evaporation)$

Where Y_i and Y_{i_His} are the modelled and observed yield of crop i (kt/year), S_i is the livestock number of livestock i (Thousand heads/year), $Y_{Crop\text{-}1\ j=i\text{-}N}$ $Y_{Crop\ j=i\text{-}N}$ are the productivity of crops in previous year and current year used for modelling number of livestock i or direct CO_2 emissions from urea and lime applications, F_i and F_{i_His} are the modelled and recorded fertiliser applied in non-irrigated and irrigated crops and pasture (kt/year), $C_{Grassland}$ is the annual C stock changes in grassland, in representing biomass produced from grassland. These values were from national inventory for grassland GHG emissions, precipitation, temperature, evaporation are the annual rainfall (mm), annual average air temperature (°C) and pan evaporation (mm).

Model validation

The RF models were evaluated against ABS crop production data and livestock numbers and/or inventoried emissions for the period 1990 to 2022. Cross validation was employed during the model validation processes whereby 80% of the dataset was randomly selected for training the model, while the remaining 20% was used to evaluate its performance. To ensure the stability of the models, this procedure was repeated 200 times for each validation process. Additionally, the cross-validation process was performed 50 times to account for model uncertainty and to better capture the impacts of climate variability and change, resulting in an optimised set of RF models.

Two metrics were used to assess model performance, the coefficient of determination (R^2) and root mean square error (RMSE). A summary of the model performance (R^2) is as follows:

- the annual yields of 11 key crops in NSW were modelled well, with correlation against ABS data of 0.79 to 0.92
- models for livestock numbers (cattle feedlot, cattle pasture, dairy cattle, and sheep) achieved correlation with ABS data ranging from 0.82 to 0.93
- fertiliser application in irrigated and non-irrigated crops achieved relatively lower correlation of 0.62 and 0.68, respectively. Fertiliser use in irrigated and non-irrigated pastures achieving higher R^2 values of 0.93 and 0.88, respectively
- for urea and lime application, using key crop productivity as a predictor variable, the models achieved correlation with historical emissions of 0.92 and 0.88.

A sample of the model results is presented in Figure 31, comparing observed (ABS statistics) and predicted (model results) for select crops and livestock.

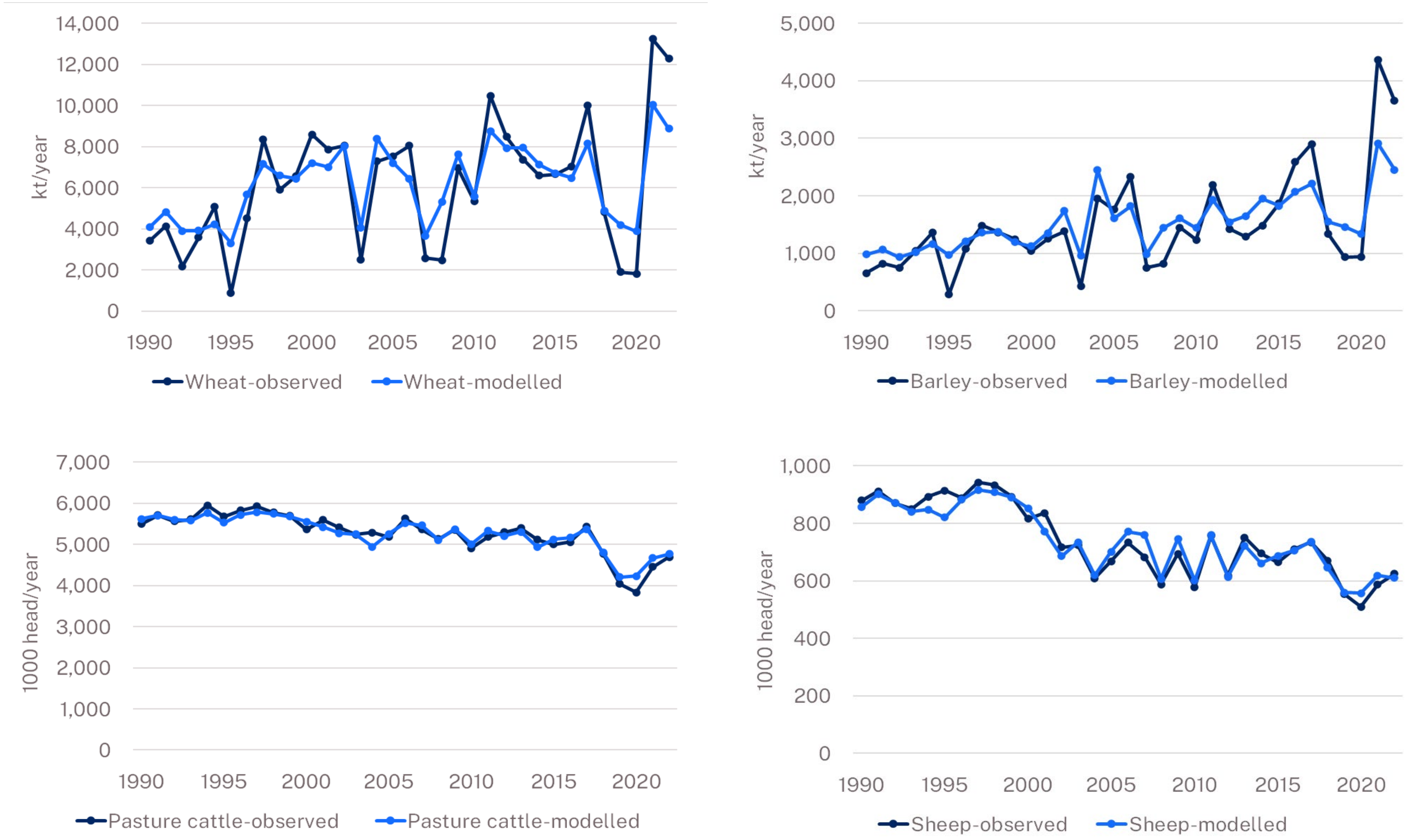

Figure 31 **Example of model validation comparing observed (ABS statistics) and predicted (model results) for select crops and livestock**

Changes in emissions since last year's projection update

The 2024 BAU emissions projections for the agriculture sector show slightly lower emissions in 2030 and slightly higher in 2035 compared to the figures published in 2023 (Figure 32). The main reason for the change in the shape of the trend is due to a change in the modelling approach, which now accounts for changes in agricultural productivity due to changing future climate (described further below).

There is an overall declining trend from 2023 to 2050, which can be partially attributed to forecasted drier conditions, resulting in lower forecasts for certain crop production and livestock activities. The declining trend is also due to an assumed improvement in emissions intensity of 1% per annum from 2025 to 2050 for sheep and cattle. This assumption is a more cautious improvement in emission intensity than corporate commitments previously reported by Meat & Livestock Australia, the National Farmers Federation and Dairy Australia.

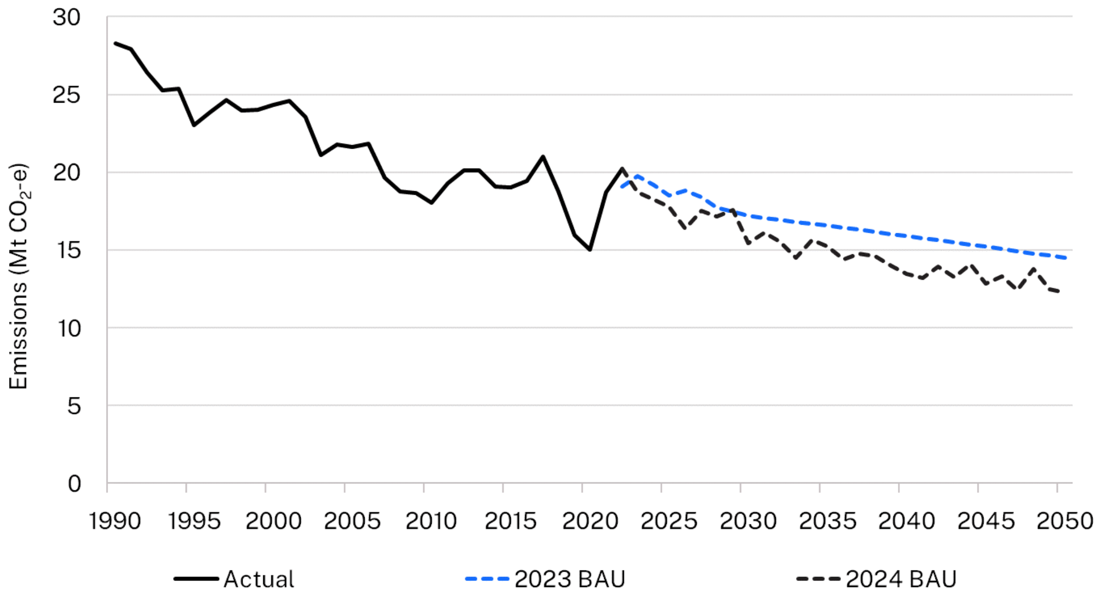

Figure 32 **Comparison of 2023 and updated 2024 BAU emissions projections for the agriculture sector**

Current policy assumptions

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). The current policy projections for agriculture assume the NSW Government can play a role in removing barriers to the adoption of abatement in this sector. Support for abatement within the agricultural sector is also assumed to leverage existing Australian Government focus and funding as well as corporate commitments.

The abatement of enteric fermentation is assumed to be prioritised for agriculture, achieved through dietary modification for dairy cattle and herd management of grazing cattle. This is assumed to be supported through future funding rounds for the Primary Industries Productivity and Abatement Program (PIPAP) and under committed funding for future stages of the Net Zero Plan. The independent peer review classified earlier assumptions for technical efficacy of enteric methane abatement as overly optimistic and not supported by evidence. For the 2024 update, a more cautious adoption rate and technical abatement potential for dietary modification was assumed (technical abatement potential of 30% with an adoption rate of 60% by 2030). Some additional abatement is also assumed for the cropping sector in the 2024 update, based on abatement potential for commercialisation of innovative ag tech, supported by the Net Zero Industry and Innovation Program (Clean Technology Innovation).

The projected abatement in the agriculture sector is shown in Figure 33.

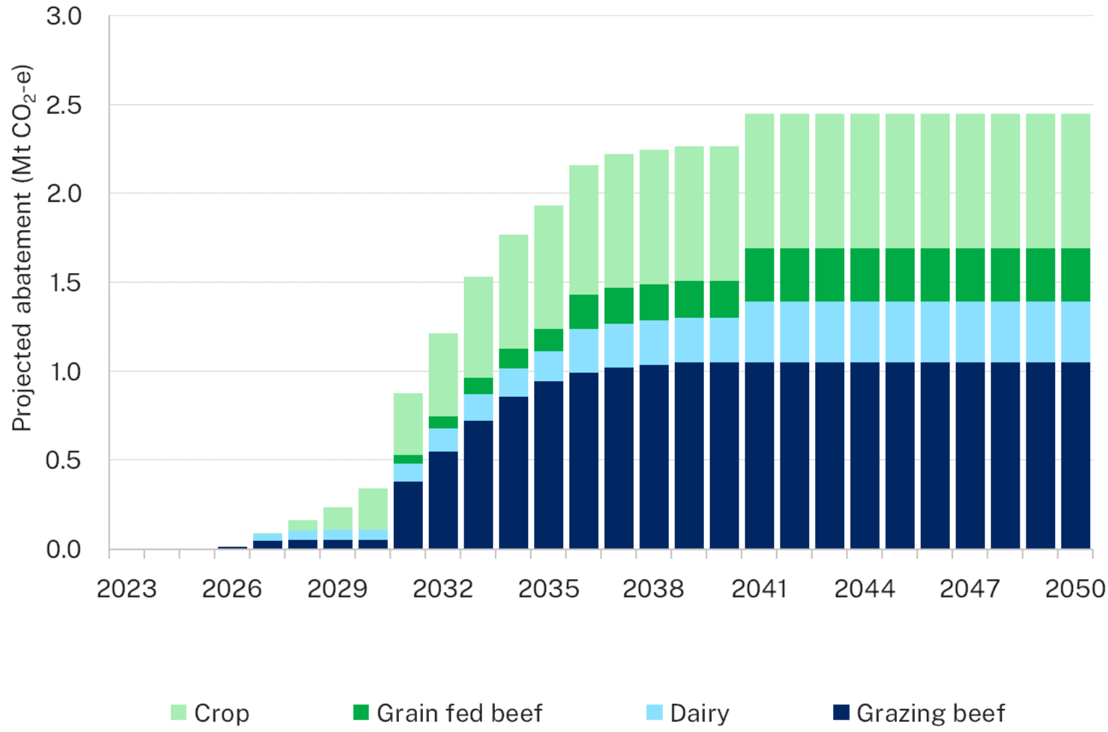

Figure 33 **Abatement of agriculture sector emissions projected to be achieved by Net Zero Plan programs and related policies (2025 to 2050)**

Limitations and considerations for future improvement

Although ML models are shown to correlate well with historical activity and emissions data, the following limitations to the approach are identified:

- land-use change (for example, changes to crop planting and pasture areas) are not included in the modelling
- market trends (for example, shifts in production practices and dietary change) are not included

- projections are based on the SSP126 (low emission) future climate scenario and therefore does not account for variability under other equally plausible future emissions/climate scenarios, especially for the subsectors more sensitive to climatic factors, such as the production of rainfed cropping and pasture systems in semi-arid and arid regions across New South Wales.

The following key research directions are identified for the sector to address limitations and continually improve model accuracy.

- Process-based modelling: develop and employ process-based models to simulate key crop production under varying climate conditions to improve yield predictions.
- Hybrid modelling approaches: develop hybrid models, integrating the process-based models with machine learning models to improve the estimates of grassland productivity, livestock numbers and associated emissions.
- Refining assumptions for swine and poultry modelling.
- Spatial modelling with land-use change integration: incorporate spatial modelling techniques that account for land-use changes, enabling more accurate predictions of crop and pasture productivity.
- Uncertainty analysis of future climate scenarios: conduct comprehensive uncertainty analyses using medium- and high-emission scenarios.

Land use, land-use change and forestry

The land use, land-use change and forestry (LULUCF) sector accounts for anthropogenic greenhouse gas (GHG) emissions and removals occurring on managed land, ‘where human interventions and practices perform production, ecological or social functions’ (IPCC 2006).

The LULUCF sector is unique in that it functions as both a source of carbon dioxide (CO_2) emissions (for example, deforestation) and as a sink of CO_2 emissions (for example, afforestation). Subsectors within LULUCF include sources associated with:

- anthropogenic activities on managed land, including the management of forest, croplands, grasslands and wetlands (the ‘land remaining’ subsectors)
- land-use change from the conversion of forest lands and grasslands to cropland and pasture and afforestation (the ‘land converted’ subsectors).

Non-anthropogenic emissions and removals due to natural causes, such as wildfires, can be substantial, and on an annual basis can swamp the overall trend in emissions and removals for the land sector. Therefore, under United Nations Framework convention on climate change (UNFCCC) reporting rules for national accounts, these events are modelled and reported to average out over time, with short-term emissions balanced by removals as the forest regrows. Therefore, emissions and removals from activity and land-use change on managed lands are the dominant inventoried source for the sector.

It is noted that the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines defines the Agriculture, Forestry and Other Land Use (AFOLU) sector. Consistent with UNFCCC reporting, agriculture and LULUCF are reported separately in Australia’s accounts. Management activities on cropland and grassland are accounted for in the LULUCF sector, while other agricultural activities are accounted for in the agriculture sector, as described previously (that is, methane (CH_4) from enteric fermentation in livestock, rice cultivation, nitrous oxide (N_2O) from manure storage, agricultural soils and biomass burning).

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-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 (BOM) Australian Hydrological Geospatial Fabric (BOM 2022) and Directory of Important Wetlands in Australia (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

NSW's LULUCF emissions since 1990 are characterised by a fluctuating trend, with the sector remaining a CO_2 sink for much of the historical timeseries. Figure 34 shows inventoried LULUCF emissions and how subsectors fluctuate as a source or sink across the timeseries.

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. For years where sequestration is greater than emissions, the LULUCF sector remains a net sink of emissions.

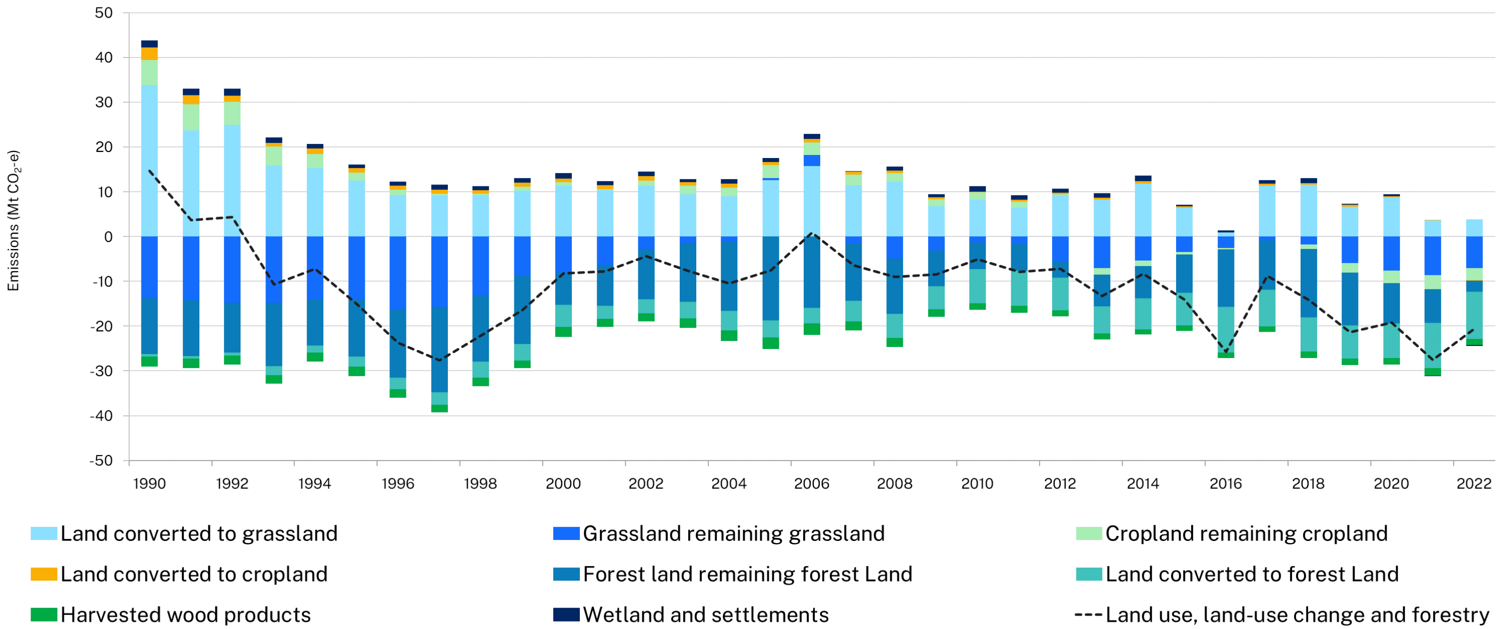

Figure 34 **Inventoried LULUCF emissions and sequestration from 1990 to 2022**

Historical trends in each subsector are summarised in Table 38.

Table 38 Summary of the historical trends in LULUCF

Subsector	Summary of trends
Forest land remaining forest land	Remains a CO_2 sink throughout the historical timeseries Fluctuations driven by the losses and gains in wood vegetation (fire, harvesting, regrowth)
Land converted to forest	Increasing trend in the CO_2 sink (declining emissions) due to forest regrowth
Grassland remaining grassland	Generally, a CO_2 sink throughout the historical timeseries Fluctuations in soil carbon sequestration driven by changing climate variables
Land converted to grassland	Declining trend in clearing for grassland, however, remains a source of emissions throughout the historical timeseries
Cropland remaining cropland	Fluctuates between a source and a sink throughout the historical timeseries Trended towards a sink for recent years
Land converted to cropland	Declining trend in clearing for cropland Remains a source of emissions for most of the historical timeseries
Forest land converted to settlements	Declining trend in clearing for settlements Remains a source of emissions for most of the historical timeseries
Harvested wood products	Remains a CO_2 sink throughout the timeseries Carbon sequestered in solid wood products, even when disposed of in landfills
Wetlands	Remains a source of emissions for all the historical timeseries, with the dominant source of emissions being CH_4 from reservoirs

Business-as-usual (BAU) emissions projections for the LULUCF sector are shown in Figure 35. Under the BAU scenario, the large emissions sink is projected to remain over the long term. Emissions from the LULUCF sector are −20.6 Mt CO_2-e for 2022, with the net sink projected to remain at −18.0 Mt CO_2-e in 2030 and −16.8 Mt CO_2-e in 2035.

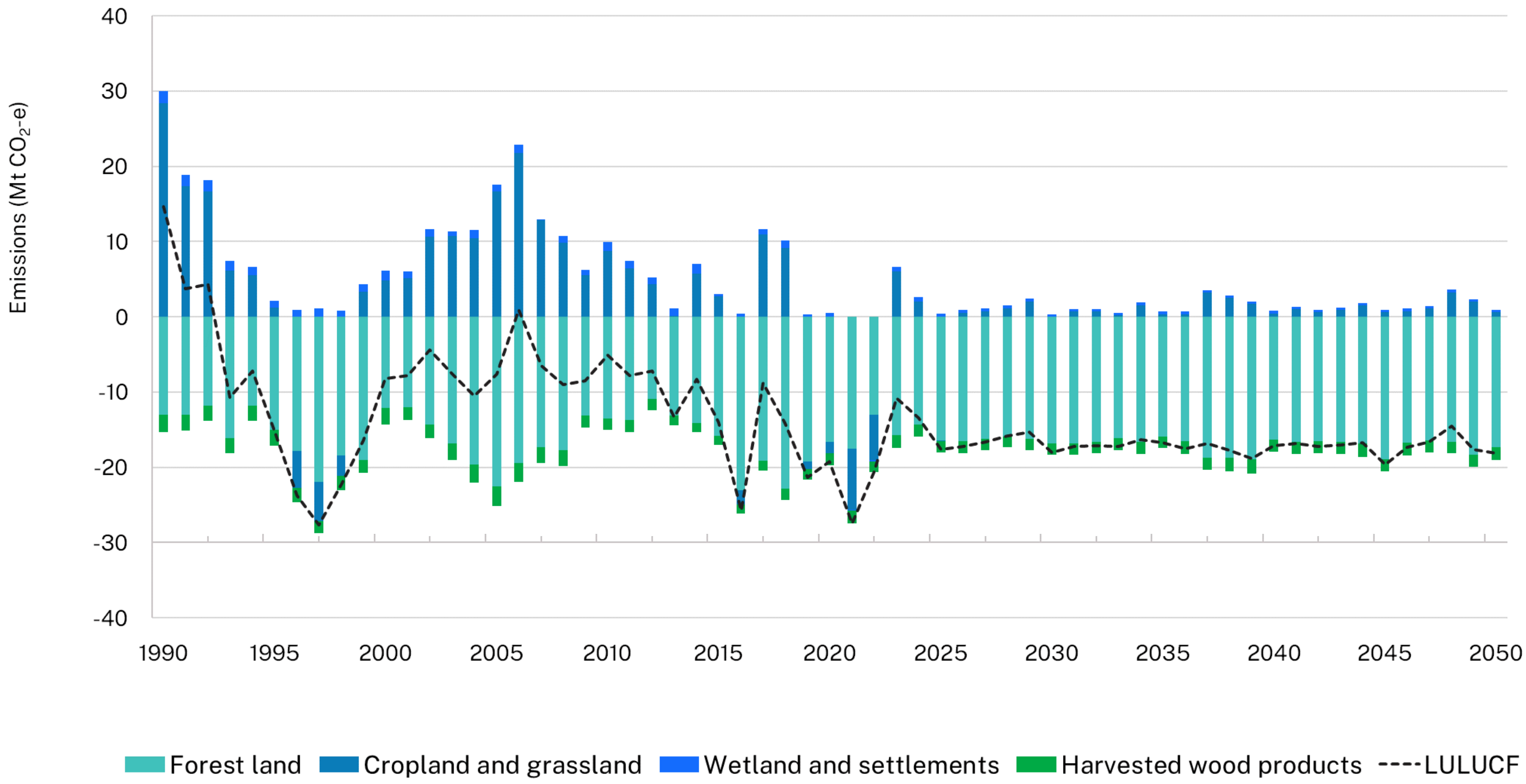

Figure 35 **LULUCF emissions and sequestration showing inventory estimates (1990–2022) and BAU emissions projections (2023 to 2050)**

Current policy projections show a very small increase in the LULUCF sink (see Figure 36).

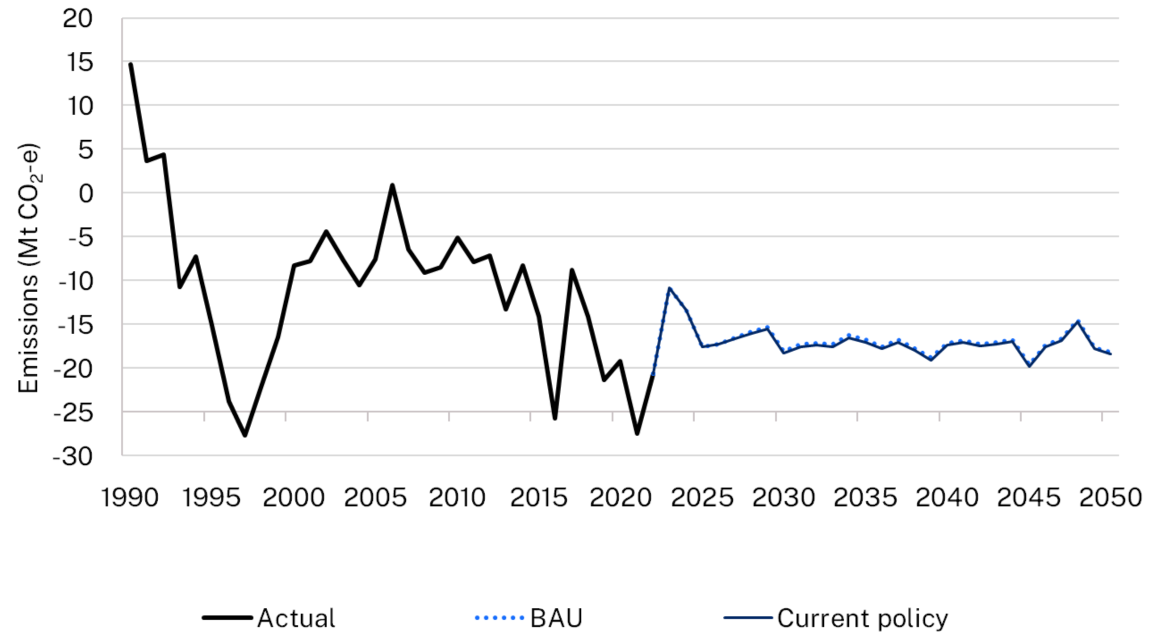

Figure 36 **NSW LULUCF sector emissions as inventoried (1990 to 2022), with BAU and current policy projection range (2023 to 2050)**

Methodology and assumptions

Previous projection updates relied on the Commonwealth's emissions projections, which were provided up to and including 2035. 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, with linear regression used to model annual variations of emissions from forest in response to the changes in annual rainfall for the period 2035 to 2050.

A refined modelling approach is used for the 2024 update, using the RF machine learning algorithm, applied to quantify the relationships between the large-scale climate indices in New South Wales and emissions from each subsector. The RF modelling approach has been previously described in the agriculture chapter.

Data inputs and approach

The key data inputs to the RF model are:

- historical GHG emissions emitted from each subsector taken from the 2022 States and Territories Greenhouse Gas Inventory (STGGI).
- historical annual climate variables, including maximum and minimum air temperature, rainfall and potential evapotranspiration (PET), obtained from the BOM

- future climate variables from 2023–2050, obtained from NARCliM 2.0 under the SSP1-2.6 (low emissions) scenario (New South Wales and Australian Regional Climate Modelling Version 2.0).

For each category of LULUCF, historical annual emissions response to past climate is modelled and used to predict future emissions based on future climate, as follows:

$$C_i = f(C_{i\_His}, Precipitation, Temperature, Evaporation)$$

where Ci and Ci_His are the predicted and historical emissions for the relevant subsector.

Model validation

The RF models were evaluated against inventoried emissions for the period 1990 to 2022. Cross validation was employed during the model validation processes whereby 80% of the dataset was randomly selected for training the model, while the remaining 20% was used to evaluate its performance. To ensure the stability of the models, this procedure was repeated 200 times for each validation process. Additionally, the cross-validation process was performed 50 times to account for model uncertainty and to better capture the impacts of climate variability and change, resulting in an optimised set of RF models.

Two metrics were used to assess model performance, the coefficient of determination (R^2) and root mean square error (RMSE). A sample of the model results is presented in Figure 31, comparing observed and predicted model results.

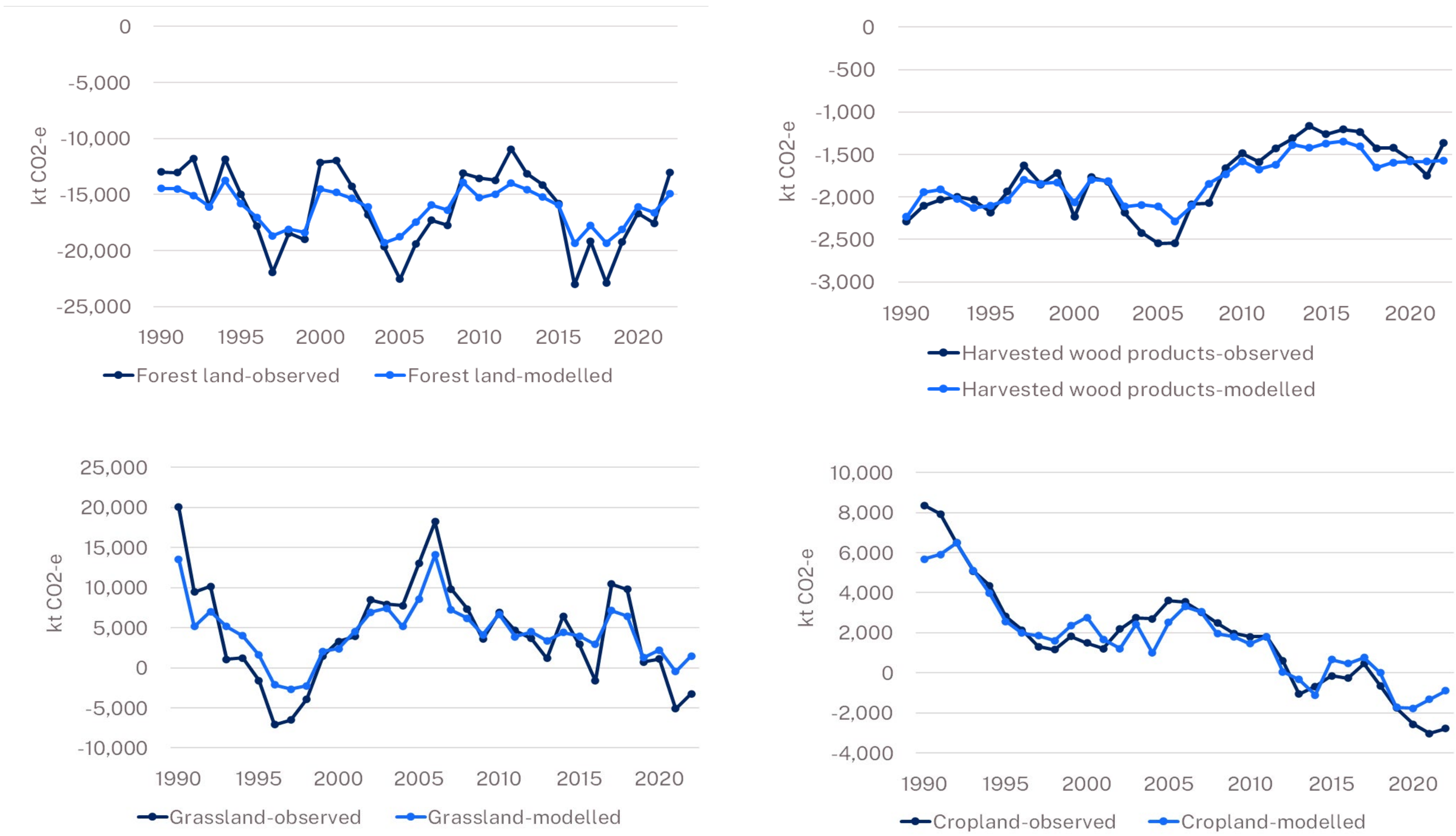

Figure 37 **Example of model validation comparing observed and predicted model results**

Changes in emissions since last year's projection update

The 2022 National Inventory Report (NIR) released in 2024 (NIR2024) included a change to the yield model in the grasslands and cropland subsectors, with yield response to climate variables significantly improved. This change has led to a recalculation across the full timeseries of inventory data and, in some years, the recalculation is significant. For example, in the 2021 NIR, released in 2023 (NIR2023), NSW LULUCF emissions were modelled to be –4.0 Mt. When recalculated in the 2022 NIR, NSW LULUCF emissions were modelled to be –27.5 Mt. For 2005, NSW LULUCF emissions were modelled to a source of emissions but when recalculated in the 2022 NIR, NSW LULUCF emissions were modelled to be –7.6 Mt.

Therefore, the updated 2024 BAU projections are modelled to be a larger sink than in 2023 BAU projections for all years from 2023 to 2050, with the LULUCF sink ranging from between 7 Mt and 15 Mt larger in the latest update (see Figure 38).

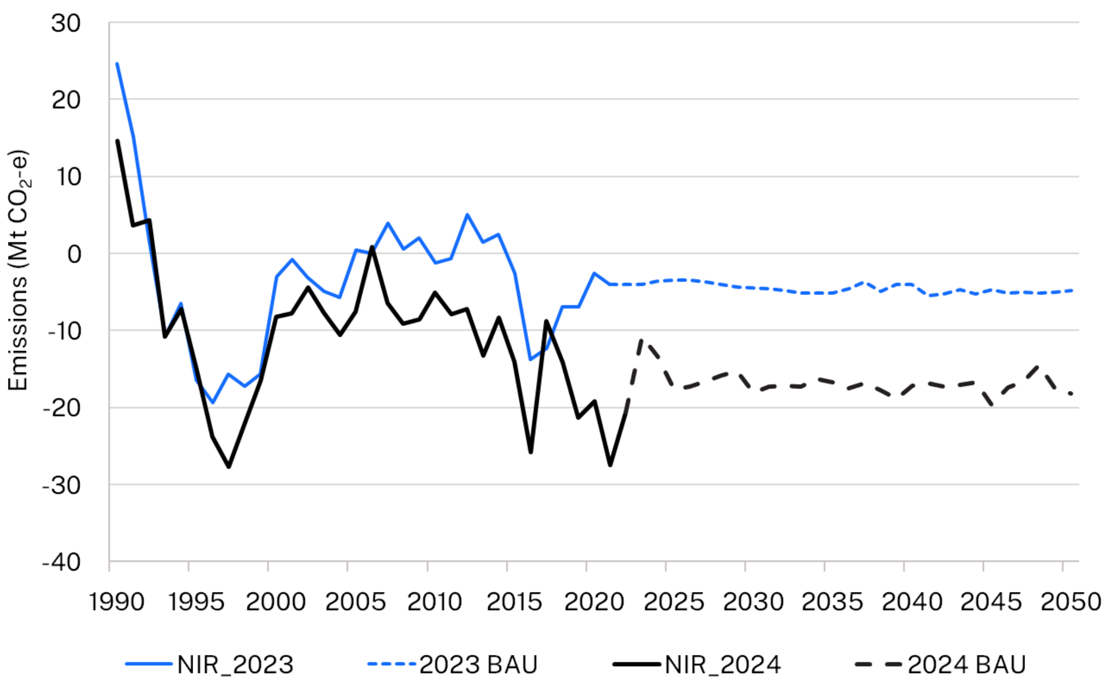

Figure 38 **NSW LULUCF emissions as inventoried in NIR 2023 and NIR 2024 and the corresponding BAU projections for the 2023 and 2024 update**

Current policy assumptions

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 (NPWS) *Carbon positive by 2028* plan (NSW Government 2022b).

Revised modelling for PIPAP considered sequestration opportunities 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 New South Wales (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 NPWS 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.

The projected abatement in the land sector is shown in Figure 39.

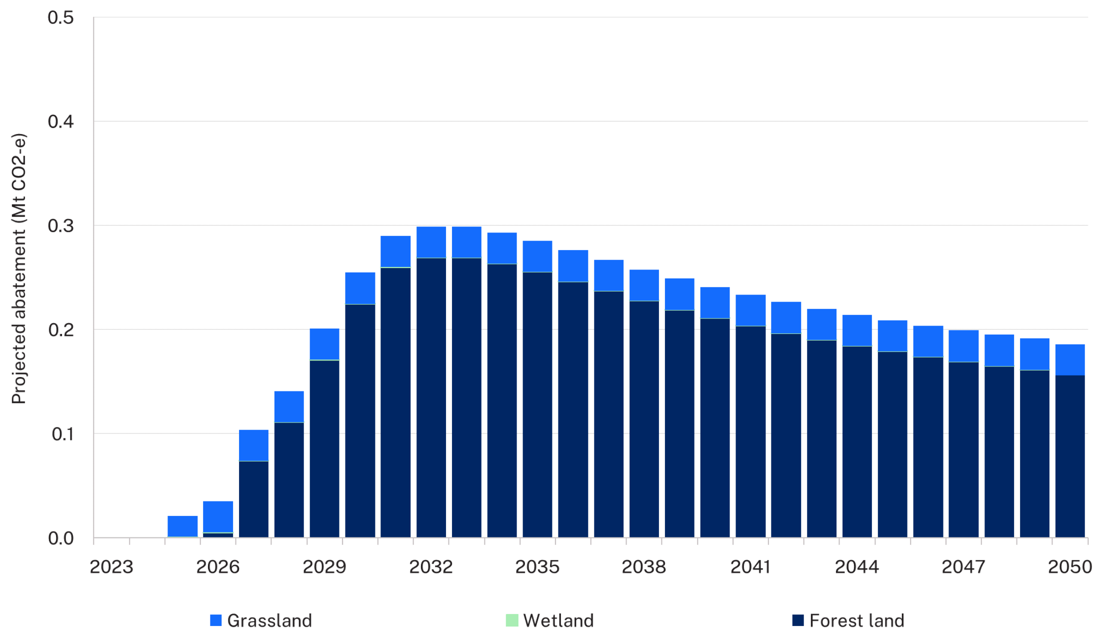

Figure 39 **Abatement of land sector emissions projected to be achieved by Net Zero Plan programs and related policies (2025 to 2050)**

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. Over the longer term, projection improvements will aim to include climate change projections within FullCAM modelling and soil carbon sequestration 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 2022 (NSW STGGI, 2024) 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 (BAU) inventoried emissions (1990 to 2022) and emissions projections (2023 to 2050) for the NSW waste sector by subsector are shown in Figure 39 for the BAU scenario and Figure 40 for the current policy scenario.

The decrease in past emissions (1990 to 2016) 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 reduction in emissions was also due to reduced waste generation per capita and increased recycling rates and diversion of waste away from landfills.

Solid waste disposal (SWD) was the largest source of emissions within the waste sector, contributing 3.4 Mt CO_2-e in 2022, accounting for 79.3% of the sector's total emissions. Domestic wastewater emissions were the second-largest contributor, totalling 0.5 Mt CO_2-e (11.8%) in 2022.

This was followed by emissions from industrial wastewater and biological treatment of solid waste, which accounted for 0.3 Mt CO_2-e (6.7%) and 0.1 Mt CO_2-e (2.1%), respectively, in 2022.

Incineration and open burning of waste was the smallest emission source, contributing 0.004 Mt CO_2-e (0.1%) of total waste sector emissions in 2022.

Under the BAU scenario, Figure 40 shows that waste sector emissions are projected to increase steadily from 4.6 Mt CO_2-e in 2023 to 4.8 Mt CO_2-e in 2035, 5.1 Mt CO_2-e in 2040 and 5.8 Mt CO_2-e in 2050.

This increase is primarily driven by a projected 75.5% population growth in New South Wales between 2022 and 2050, adding approximately 2,651,963 people.

Figure 41 shows the emission reductions under current policy settings, primarily driven by solid waste disposal, followed by domestic wastewater and industrial wastewater subsectors. Under current policy, emissions from the waste sector are projected to decrease by 1.5 Mt CO_2-e (35% reduction) by 2035, reaching 2.8 Mt CO_2-e. From 2035 onwards, emissions are expected to gradually increase, with projections of 3.0 Mt CO_2-e in 2040 and 3.34 Mt CO_2-e in 2050.

Solid waste disposal will remain the largest source of emissions within the waste sector, contributing 3.5 Mt CO_2-e (76%) in 2023, declining to 1.4 Mt CO_2-e (52%) in 2035, 1.5 Mt CO_2-e (51%) in 2040 and 1.5 Mt CO_2-e (46%) in 2050. Despite an overall decrease in relative contribution, solid waste disposal emissions are expected to grow in absolute terms due to increased waste generation.

Domestic wastewater emissions are the secondary source of emissions and are expected to increase over time, contributing 0.86 Mt CO_2-e (26%) of total waste sector emissions by 2050, from 0.65 Mt CO_2-e (14%) in 2023. Industrial wastewater emissions will follow, contributing 0.5 Mt CO_2-e (18%) in 2035, 0.6 Mt CO_2-e (19%) in 2040, and 0.81Mt CO_2-e (24%) in 2050.

Biological treatment of solid waste and incineration and open burning of waste will account for only 0.1 Mt CO_2-e (3%) of total waste sector emissions.

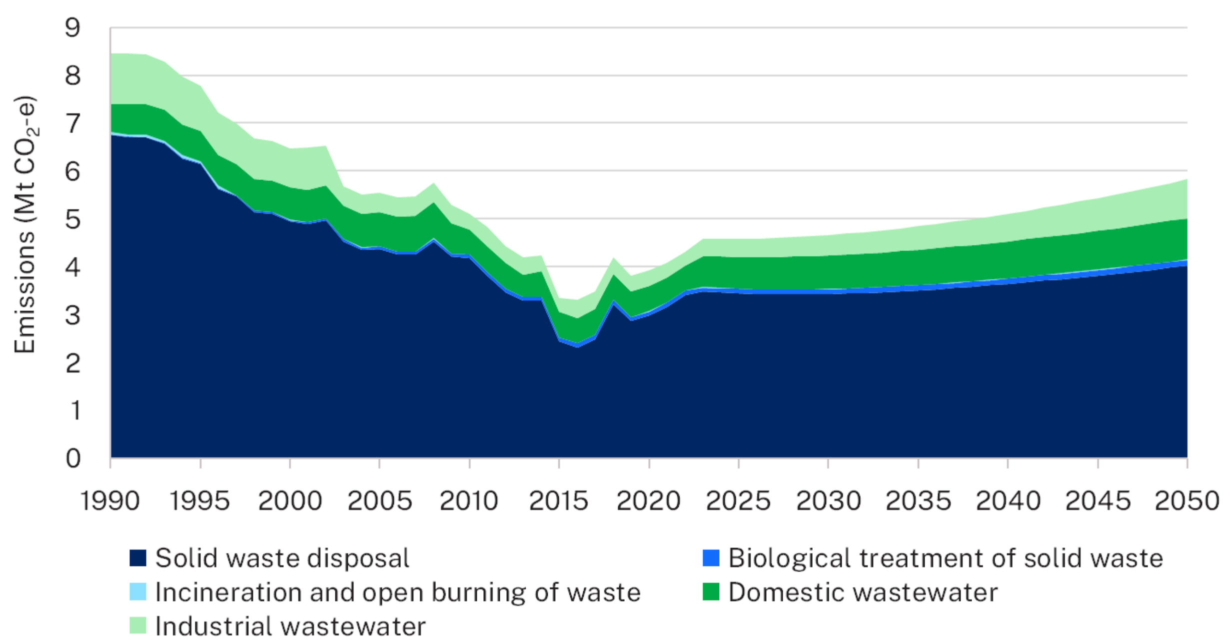

Figure 40 **Waste emissions by subsector showing inventory estimates (1990 to 2022) and BAU emissions projections (2023 to 2050)**

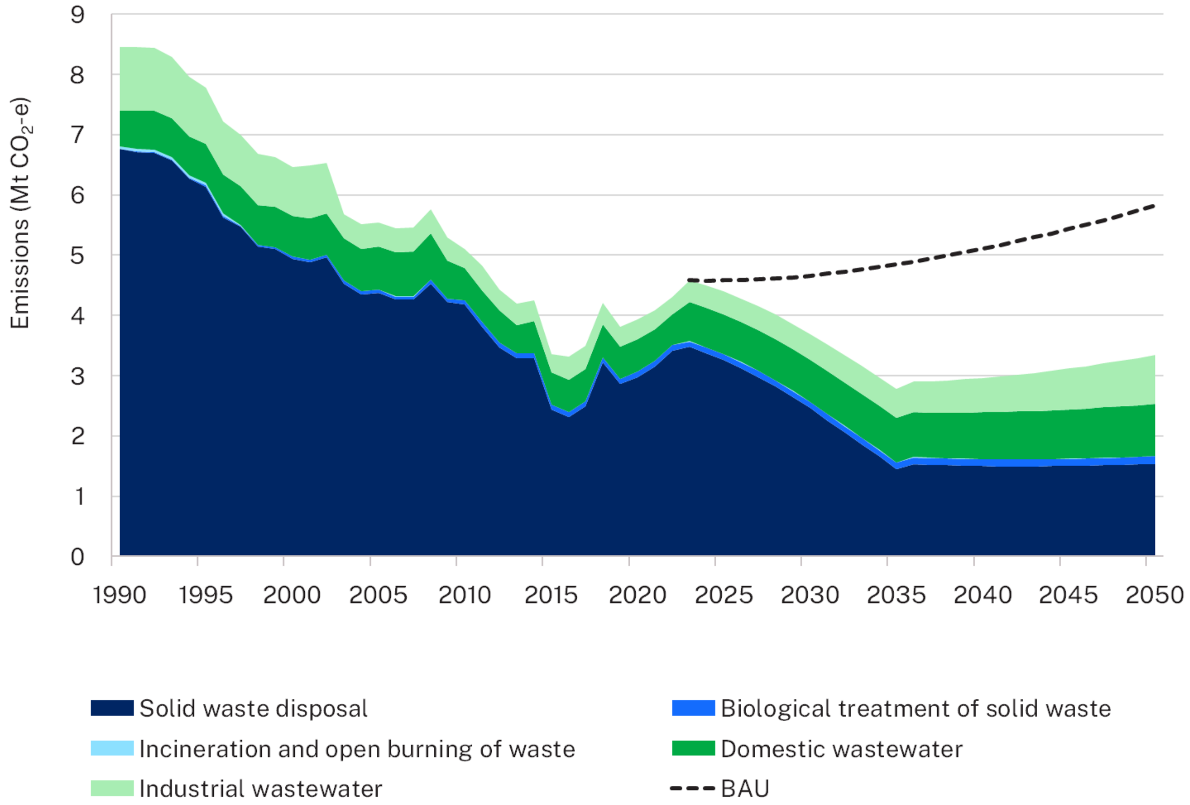

Figure 41 **Waste emissions by subsector showing inventory emissions (1990 to 2022) and current policy emissions projections (2023 to 2050)**

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 States and Territories Greenhouse Gas Inventory (STGGI) data over the period 2015 to 2022, 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 (that is, % 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 Australian Government's Department of Climate Change, Energy, the Environment and Water (Cth DCCEEW) and more contemporary data from the NSW Environment Protection Authority's (EPA) WARRP (EPA 2023c), noting that detailed individual landfill data is strictly confidential. It also relies on Cth DCCEEW's estimates of gas capture (that is, 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 25 large landfills are responsible for 63% and 60% of waste disposed in New South Wales in 2021–22 and 2022–23, 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 2022–23 the capture efficiency was 16%.

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 its 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 to 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 to 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 25 specific landfills (26 including 'residual NSW') in the Cth DCCEEW dataset cannot be verified due to a lack of historical record keeping and data availability.

Activity data inputs for GHG emissions projections

- Cth DCCEEW historical (FYs 1940 to 2014) waste stream data (that is, tonnes of MSW, C&I, and C&D) are from the Cth DCCEEW solid waste spreadsheet model. FYs 2015 to 2023 use the NSW EPA WARRP data.
- Waste disposal projection data beyond 2021–22, use assumptions outlined in the NSW EPA 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 to 2023) are from the Cth DCCEEW solid waste spreadsheet model.
- Gas capture beyond 2022–23, 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 (that is, 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 2022-23 (obtained from Cth DCCEEW's dataset) is the initial value for gas capture, that is, the (t–1) value.

- Annual gas capture rates vary dynamically across the multiple sites categorised under the 'residual NSW'. To account for this variability, the projected capture rates for the current policy gas capture scenarios are capped at the historical median from 2010 to current reporting year. This approach avoids using the maximum value of projected rates as a ceiling value leading to 2030 as used in the previous year's update. The median compounded with fixed general growth rate, provides a plausible long-term forecast while avoiding overestimation.
- 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%
  - 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 to 2050)
  - C&D waste, the rate of increase is in line with projected increases in building activity, an average of 1.8% from 2021 to 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 to 2050. Modest improvements in gas capture rates as per Cth DCCEEW projections are assumed, based on the Blue Environment (2019) methodology.

The Cth DCCEEW'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 landfills and 'residual NSW'. All landfills are 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 2022–23, WARRP data were used, with all waste disposal summed across the approximately 300 landfills in New South Wales and the waste disposed of the 25 landfills that are individually modelled subtracted. Cth DCCEEW waste mix percentages as at 2017–18 were adopted.

The annual CH_4 captured, flared or transferred (units t CO_2-e) at each landfill was derived from the annual CH_4 generated. The net CH_4 emissions at each landfill are then summed to produce net CH_4 emissions for New South Wales. The overall gas capture rate for all NSW landfills is currently 40% for 2022–23, and is projected to increase to 51% by 2050, with an average projected rate of 47% over the period 2023 to 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 NSW DCCEEW 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 and 2024b). 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 such as 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' chapter)
- 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 of the 'Waste' chapter)
- 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 39 to estimate historical emissions from 2015–16 to 2021–22.

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 372 kt CO_2-e or 58% of NSW domestic and commercial wastewater treatment emissions (total of 641 kt CO_2-e for 2021–22).

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 342 kt for 2021–22.

Data sources

Foundational datasets used in the estimation and disaggregation of wastewater treatment emissions are listed in Table 39.

Table 39 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 2021–22	NSW wastewater treatment emissions	Total NSW emissions disaggregated by IPCC category and subcategory	STGGI data for category 5D (domestic and commercial, industrial) (Cth DCCEEW 2024a)
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

Data reference	Description	Resolution	Source
NPI data 2022–23	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 (2021–22)	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 2020 to 2041 are based on the Australian Statistical Geography Standard 2022 LGA population projections as provided by the NSW DPHI at project inception. These population projections were developed by the NSW DPHI from the NSW Treasury's NSW Common Planning Assumptions as published in November 2024 (DPHI 2024).

The future population projection for the periods 2041–42 to 2049–50 was not available. To calculate population growth, the population forecast data supplied by NSW DPHI (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 to 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.

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 42). 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 43). 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.

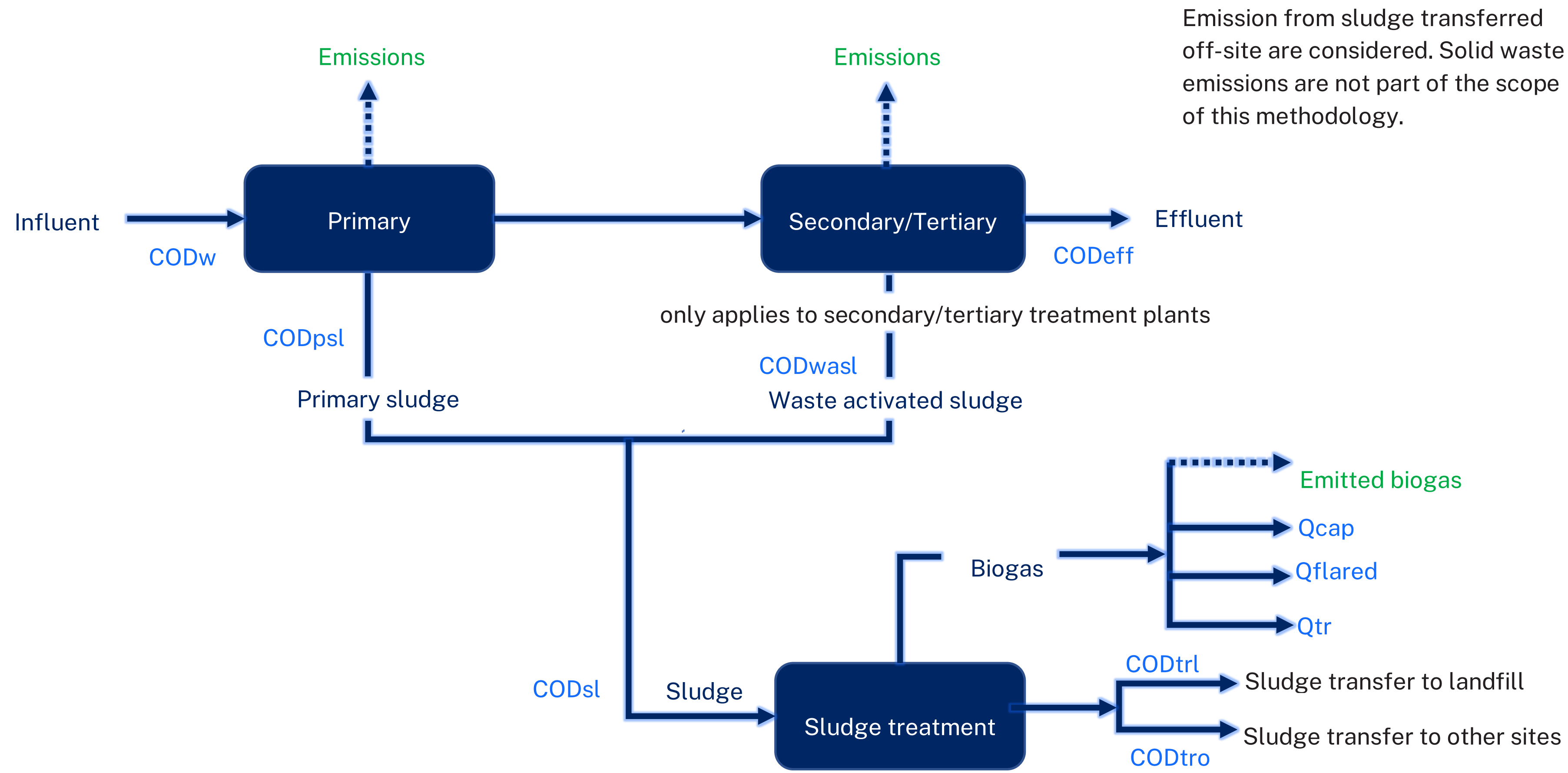

Figure 42 Pathways for methane (CH_4) emissions from domestic and commercial wastewater handling

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

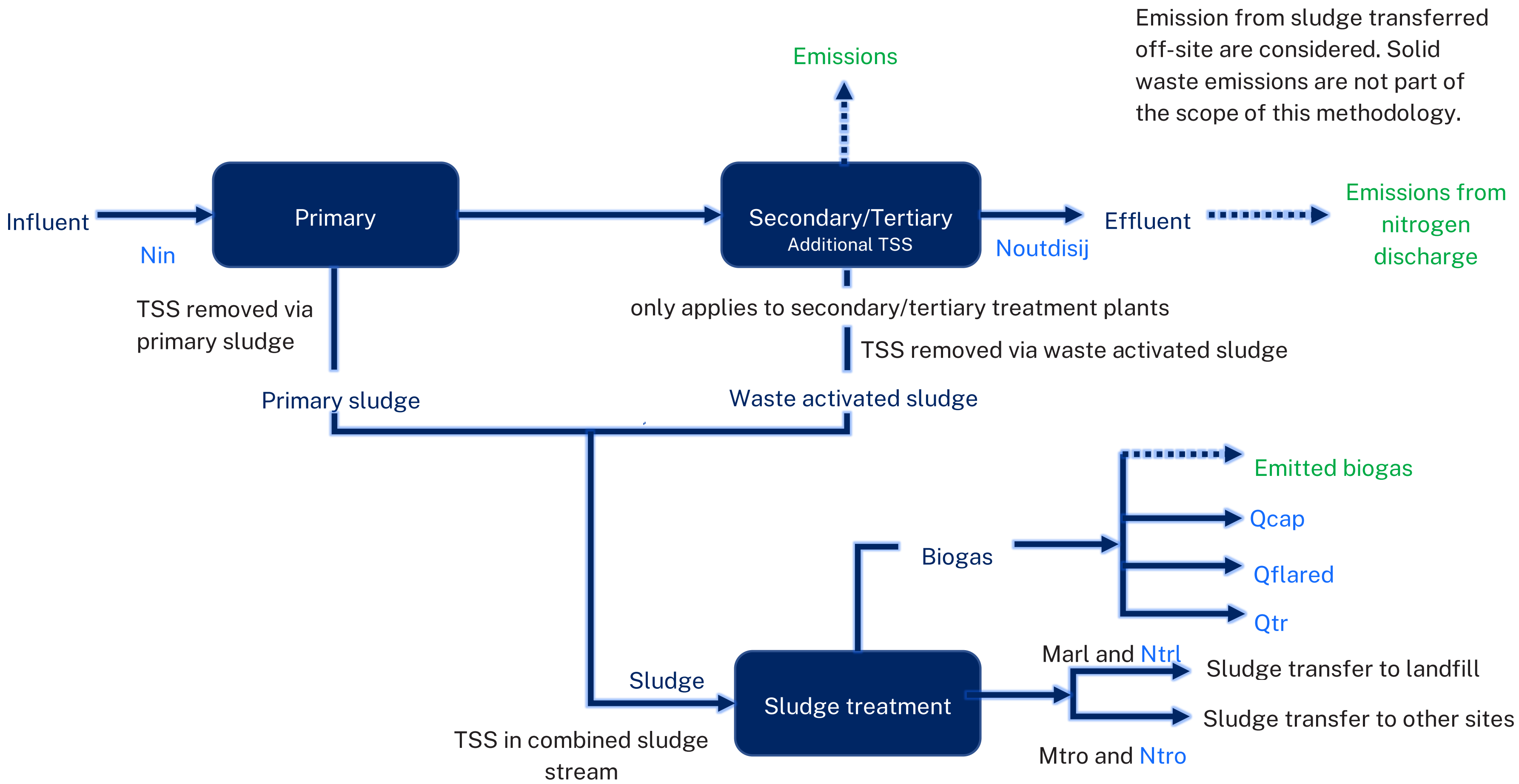

Figure 43 **Pathways for nitrous oxide (N_2O) emissions from domestic and commercial wastewater handling**

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 such as 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 2022 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 40.

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 40 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 NSW DPE projections (DPE 2022g) were used to project the inventory into future years using the population growth metric discussed earlier.

Industrial wastewater treatment

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 2020 to 2024 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 41.

Table 41 Data transformations for historical national commodity production

Sector	Data transformation
Beer	Input figures adapted from Cth DCCEEW-provided annual production figures (in L) using assumed conversion of 1.015 kg/L
Dairy	Input figures adapted from Cth DCCEEW-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 (that is, 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 42 Industrial sectors for assessment with Australian and New Zealand Standard Industrial Classification (ANZSIC) code. 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 42 **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 vegetables	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 several 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 43.

Table 43 Methodology summary – economic forecasting of sector growth and commodity production

Component	Details
Inputs	Gross value added (GVA) for agricultural industrial activities Australian Bureau of Statistics (ABS) general population of Australia 2011–2016 employment figures for the 116 identified facilities
Calculations	GVA per person GVA per sector Compound annual growth rate (CAGR) Eof 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 (that is, if 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 NSW DCCEEW 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 44, which are incorporated into the model as factors.

Table 44 Compound annual growth rate (CAGR) results for each industrial sector

Sector	CAGR of sector
Dairy	−1.13%
Paper	-5.04%
Meat	4.78%
Organic chemicals	0.57%
Sugar	0.88%
Beer	1.12%
Wine	1.36%
Fruit and vegetables	−0.28%

The growth rates from Table 44 are applied to each facility, thus providing a forecast of annual employment numbers 2024 to 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. Therefore, 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 (2022), with the 2023 to 2030 trend continued to 2050 (Cth DCCEEW 2023d).

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

Emissions from the waste sector are projected to be lower than the previous update, driven primarily by changes in the solid waste subsector. The change is partly due to a decrease in the 4-year NSW Treasury forecast for the gross state product, leading to a decrease in the tonnes of waste from the construction and demolition (C&D) streams projected to be disposed of at landfill sites. Another factor affecting emissions is the increase in landfill gas capture rates beyond 2022. In the current update, the actual landfill gas capture rate for the year 2022 increased to 40% from the projected 39% in the 2021–22 FY update. The methodology used to project CH_4 capture efficiency per landfill for the period between2023 and 2050 resulted in higher overall gas capture for that period. Considerable effort will be required in landfill gas capture efficiencies if noteworthy reductions are to be made in the waste sector.

Current policy assumptions

The *Waste and Sustainable Materials Strategy 2041: Stage 1 2021–2027* (DPIE 2022b) includes targets for 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.

Abatement modelling for the 2024 projections update is based on waste diversion targets as follows:

- 50% reduction 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 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
- 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).

No specific targets for landfill gas capture and future net zero requirements for landfills have been set to date. The current rate of landfill gas capture varies between an actual 40% in 2022 to a projected 51% in 2050, with an average of 47% 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.

Therefore, abatement modelling for the 2024 projections is based on this plausible scenario of an overall increase in landfill gas capture rate to 75% by 2035 (MRA Consulting 2020). Beyond 2035, the gas capture rate remains relatively steady to 2050. To get to an overall capture rate of 75%, 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.

The projected abatement in the waste sector (applied to the disposal of solid waste subsector) is shown in Figure 44.

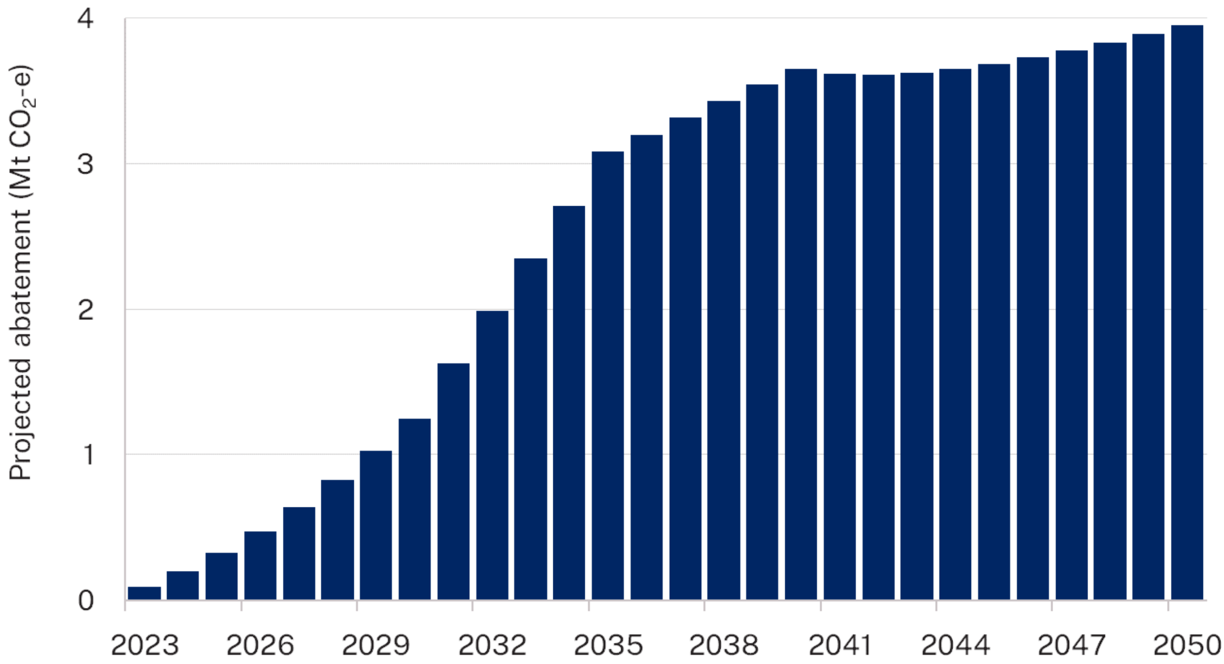

Figure 44 **Abatement of waste sector emissions projected to be achieved by Net Zero Plan stage 1 programs (2023 to 2050)**

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.

Uncertainty in emission projections

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 45).

Table 45 **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 46.

Table 46 **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 to 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.

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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
Australian Energy Statistics	AES	The official source of energy statistics for Australia

Term	Shortened form	Description
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
Coke oven gas	COG	A fuel gas produced during the manufacture of metallurgical coke

Term	Shortened form	Description
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
Enteric fermentation		A ruminant digestive system process by which plant material is broken down by bacteria in the gut under anaerobic conditions

Term	Shortened form	Description
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
Hydrofluorocarbons	HFCs	Often used as refrigerants, HFCs are a GHG used as substitutes for chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs)

Term	Shortened form	Description
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 to 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
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

Term	Shortened form	Description
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 to 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
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*.

Term	Shortened form	Description
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	ODS	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 Energy Terminal	PKET	A liquefied natural gas 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
Reporting		The presentation of data to internal and external users that include regulators, the general public or specific stakeholder groups

Term	Shortened form	Description
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
State and Territory Greenhouse Gas Inventory	STGGI	An inventory of GHG emissions for Australian states and territories

Term	Shortened form	Description
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 Wales	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