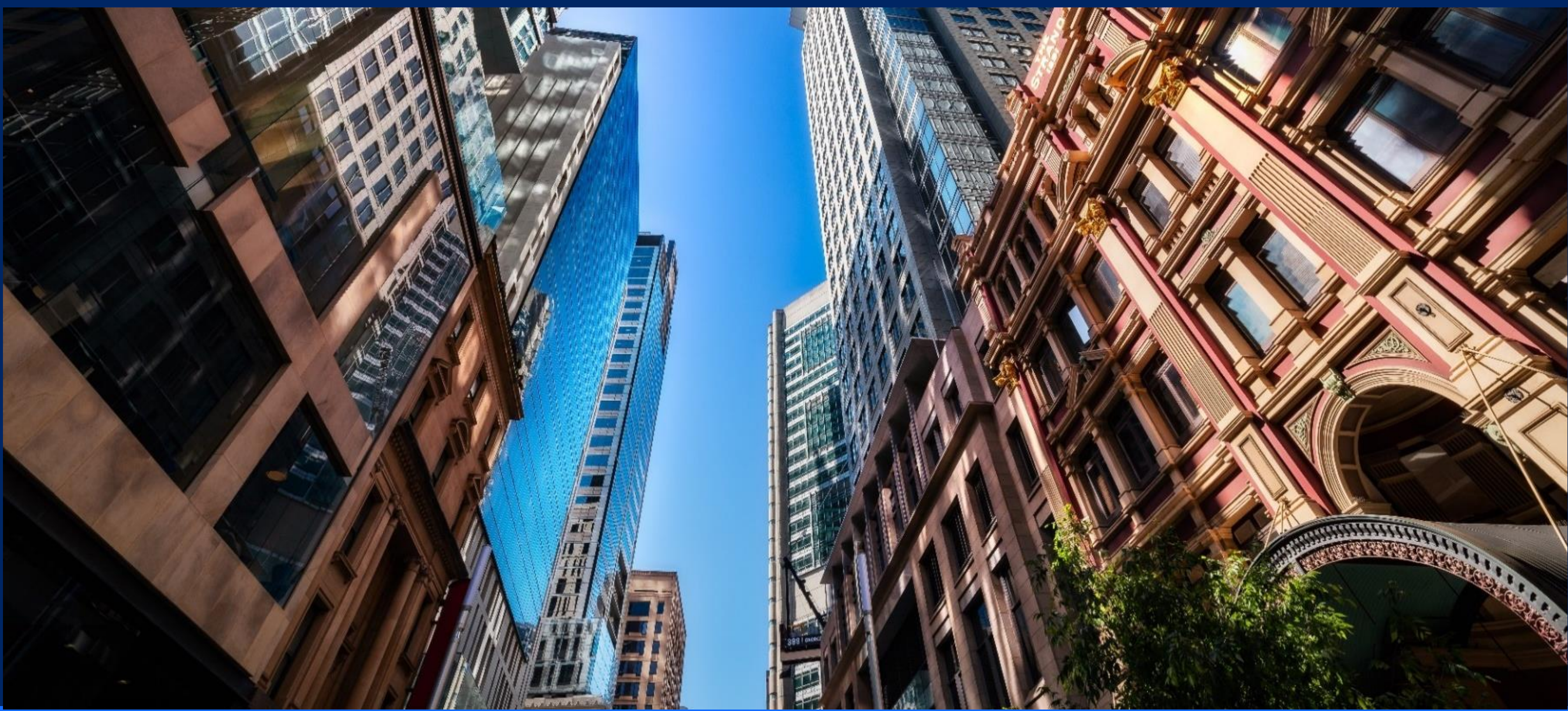
NSW Productivity and Equality Commission

Decarbonising buildings, industry, and waste

Achieving net zero

Paper 2

March 2025



Acknowledgement of Country

We acknowledge that Aboriginal and Torres Strait Islander peoples are the First Peoples and Traditional Custodians of Australia, and the oldest continuing culture in human history.

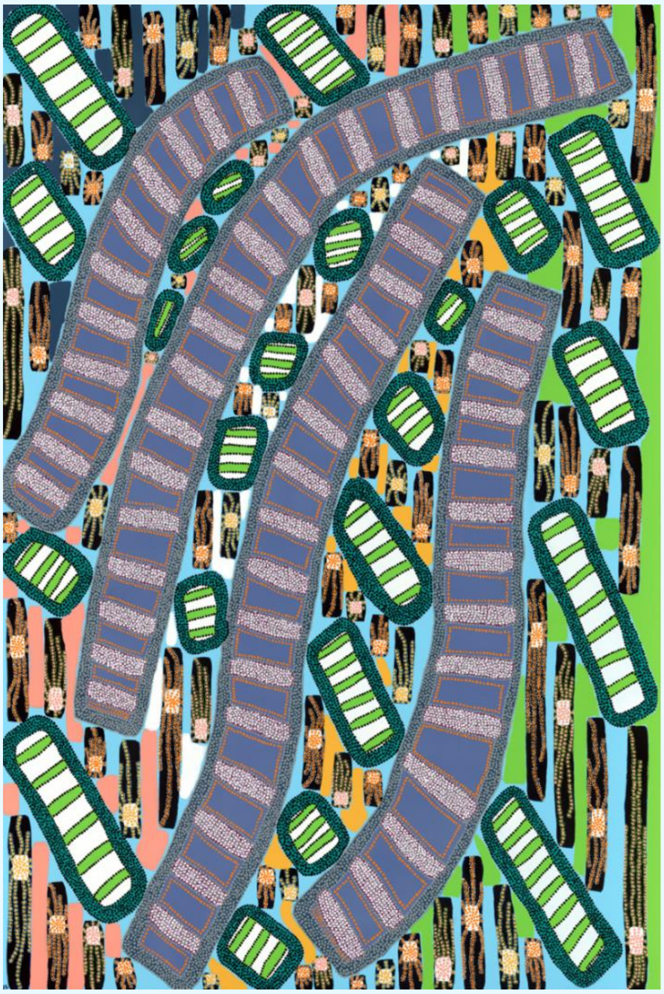
We pay respect to Elders past and present and commit to respecting the lands we walk on, and the communities we walk with.

We celebrate the deep and enduring connection of Aboriginal and Torres Strait Islander peoples to Country and acknowledge their continuing custodianship of the land, seas, and sky.

We acknowledge the ongoing stewardship of Aboriginal and Torres Strait Islander peoples, and the important contribution they make to our communities and economies.

We reflect on the continuing impact of government policies and practices and recognise our responsibility to work together with and for Aboriginal and Torres Strait Islander peoples, families, and communities, towards improved economic, social, and cultural outcomes.

Artwork:
Regeneration by Josie Rose



About the NSW Productivity and Equality Commission

The NSW Productivity and Equality Commission (formerly the NSW Productivity Commission) was established by the NSW Government in 2018 under the leadership of its inaugural Commissioner, Peter Achterstraat AM.

Productivity growth is essential to ensure a sustained growth in living standards for the people of New South Wales, by fully utilising our knowledge and capabilities, technology and research, and physical assets. The Commission is tasked with identifying opportunities to boost productivity growth in both the private and public sectors across the state. The Commission seeks to continuously improve the NSW regulatory policy framework and identify levers that can increase competition to deliver better and more affordable goods and services for NSW residents.

The Commission's priorities include:

- productivity and innovation
- fit-for-purpose regulation
- efficient and competitive NSW industries
- climate resilient and adaptive economic development.

The Commission provides objective, evidence-based advice to the Government.

In 2024, Mr Achterstraat was reappointed for a further two years in the expanded role of Productivity and Equality Commissioner. In performing its functions, the Commission considers equity and how costs and benefits are distributed across the community and over time. For instance, the Commission's research on housing examines the equity and environmental benefits of policies and reforms to improve housing affordability, beyond the overall productivity and economic benefits.

The Commission regularly engages with stakeholders to ensure its research and recommendations are well-informed and to encourage a public conversation on productivity reform.

Disclaimer

The views expressed in this paper are those of the NSW Productivity and Equality Commission alone, and do not necessarily represent the views of NSW Treasury or the NSW Government.

Regarding the recommendations in this paper, NSW Productivity and Equality Commission recommendations only become NSW Government policy if they are explicitly adopted or actioned by the NSW Government. The NSW Government may adopt or implement recommendations wholly, in part, or in a modified form.

Commissioner's foreword

This paper is the second in the NSW Productivity and Equality Commission's *Achieving net zero* series. Our first, *Ensuring a cost-effective transition*, examined how the state is tracking toward our legislated greenhouse gas emissions reduction targets. It also outlined how we can close the gap between those targets and the most recent emissions projections.

The net zero transition is well underway — albeit with some hiccups — in electricity, as discussed in our first paper. But energy is about more than electricity. And emissions come from other sources besides coal power plants. Fossil fuels are combusted across countless sites in all sectors of our economy. All this will need to be addressed if we are to achieve net zero while keeping productivity and living standards high. And the clock is ticking.

This paper examines the net zero transition in our buildings — residential, commercial, and industrial — and in our manufacturing, construction, mining, and waste sectors. In the majority of cases, the technological solutions to reach net zero are available. But their take-up is not at a pace consistent with our legislated targets for 2030, 2035, and 2050.

We must pick up the pace of the transition by sending efficient regulatory and pricing signals to businesses and households. In preparing this paper, I was delighted to learn how the State already has the tools to do this in a way that complements existing Commonwealth and NSW Government policies. Pursuing them can spur investment in zero-emissions technologies. This can, at once, boost productivity and moderate the cost of living, of particular benefit to low- and middle-income households.

Action sooner, not later, can ensure the New South Wales of 2050 will be a net zero economy while also being one of the best places in the world to live, work, start a business, and raise a family.

Peter Achterstraat AM

NSW Productivity and Equality Commissioner

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Figures, boxes, and tables

Abbreviations

ACCU	Australian Carbon Credit Unit
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
CBAM	Carbon border adjustment mechanism
CCS	Carbon capture and storage
CEFC	Clean Energy Finance Corporation
CER	Clean Energy Regulator
CO_2-e	Carbon dioxide equivalent
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCCEEW	NSW Department of Climate Change, Energy, the Environment, and Water Note: The federal Department of Climate Change, Energy, the Environment, and Water is referred to in this paper as DCCEEW (Commonwealth)
DCP	Development Control Plan
DPE	NSW Department of Planning and Environment
DRI	Direct reduced iron
EAF	Electric arc furnace
EPA	NSW Environment Protection Authority
EV	Electric vehicle
GHG	Greenhouse gas
IEA	International Energy Agency
IPPU	Industrial processes and product use
IRA	*Inflation Reduction Act 2022* (US)
ISP	Integrated System Plan
LNG	Liquefied natural gas
LULUCF	Land use, land use change, and forestry
Mt	Megatonne (1 million tonnes)
NEM	National Electricity Market
NGER	National Greenhouse and Energy Reporting
NGERS	National Greenhouse and Energy Reporting Scheme
NSW P&EC	NSW Productivity and Equality Commission
NZIIIP	Net Zero Industry and Innovation Investment Plan
RRO	Retailer Reliability Obligation
SEPP	State Environmental Planning Policy
SMC	Safeguard Mechanism Credit
VPP	Virtual power plant

Executive summary

New South Wales needs new policies to further cut greenhouse gas emissions. Buildings, manufacturing, construction, mining, and waste all provide opportunities.

- New South Wales will not meet its legislated emissions reduction targets without doing more to cut emissions in our buildings, manufacturing, construction, mining, and waste sectors.
- Many of the technologies to meet our targets either already exist or are in development. Government needs to offer more policy incentives to get these technologies into use.
- Pricing emissions remains the cost-effective pathway. If that is not possible, high-quality regulation that passes cost-benefit analysis with accurate carbon values is essential to keeping transition costs low.

The emissions created by the sectors discussed in this paper represent approximately one third of the state's total emissions. The NSW P&EC estimates that, by 2050, these sectors will account for half of all emissions in New South Wales based on our current policy settings and pace of abatement. That is why it is so important to accelerate emissions reduction in these sectors if we hope to reach a net zero outcome by 2050.

Buildings

Buildings are the source of stationary energy emissions from burning fossil fuels to heat and cool them and provide amenities such as cooking. Emissions from the onsite burning of gas, however, cannot be so easily abated. Renewable gas still emits greenhouse gases, green hydrogen faces logistical challenges, and gas appliances are reaching their efficiency limit.

As a result, decarbonising our building stock means we must end most gas use. Specifically, we need to:

- electrify existing buildings, replacing fossil fuels with renewables-generated electricity
- end almost all gas connections for residential, commercial, and industrial developments
- offset emissions for any connections that remain.

Manufacturing and construction

Manufacturing and construction emissions come from the combustion of gas and liquid fuels for energy and from certain chemical processes such as concrete or ammonia production. These totalled 17.4 Mt CO_2-e in 2021-22. The Commonwealth Safeguard Mechanism[1] covers 61 per cent of the state's manufacturing sector and is driving abatement, but only at a slow pace.

Several key technologies are available to decarbonise these industries. But challenges will remain where high-heat industrial processes rely on natural gas and metallurgical coal.

- Electrification – directly replacing fossil fuel combustion with renewables-generated electricity.
- Green hydrogen can be burned in place of natural gas, but this technology is not yet commercially viable.
- Other renewable gases might also play a role in decarbonising difficult-to-abate activities.
- Where direct abatement is not possible, carbon capture and storage might be able to mitigate emissions. But, short of a breakthrough that makes this technology commercially viable, this is likely to require high carbon prices.
- Australian Carbon Credit Units (ACCUs) can be also employed to offset emissions.

Mining and extraction

Coal mining emissions dominate this sector, accounting for more than 95 per cent of total mining and extraction emissions. These are driven by the burning of diesel fuel to power plant and equipment, by use of ammonium nitrate, and by 'fugitive' greenhouse gas emissions escaping from mines.

The current trajectory for mining emissions has them falling significantly over the coming decades as mine licences expire and coal mines close. The Commonwealth Safeguard Mechanism prices 89 per cent of emissions from mining activities, but the current pace of abatement is slow. Licensing regimes can provide certainty for future mining operations by clearly establishing:

- licence expirations
- expectations around emissions management.

Many technologies exist to decarbonise the mining sector's ongoing operations. Options include reducing fugitive emissions through capture and flaring[2] (particularly for underground mines), and electrifying plant and equipment.

[1] The Commonwealth Safeguard Mechanism requires Australia's highest-emitting facilities to cut their emissions in line with Australia's emission reduction targets.

[2] Flaring burns methane, turning it into carbon dioxide, to dramatically reduce its potency as a greenhouse gas.

Waste

Most waste sector emissions in New South Wales come from decomposing landfill and wastewater treatment. Waste emissions are projected to fall in the medium term, as we roll out methane capture and cut the amount of waste that is sent to landfill.

Many technologies exist to further reduce waste emissions, but any investment should be consistent with the principles of a least-cost transition.

Only some waste facilities are covered by the Commonwealth Safeguard Mechanism, but the State has existing tools to apply a similar emissions pricing approach to uncovered facilities.

1 Introduction

The technological solutions to hit our legislated targets are available, but more policy incentives are needed to dial-up efforts.

1.1 The NSW Productivity and Equality Commission's previous work on the net zero transition

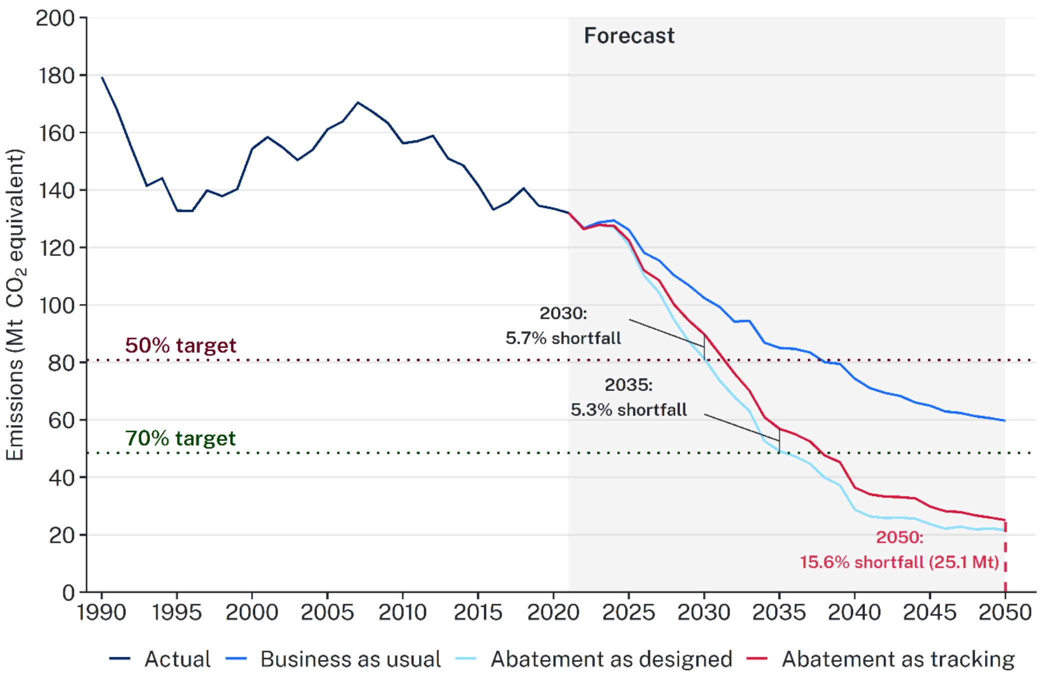
This paper is the second in the *Achieving net zero* series. The first paper focused on the current emissions landscape, emissions reduction targets for New South Wales, and the extent of our progress.

New South Wales, along with the Commonwealth and all other states and territories, has committed to net zero emissions by 2050. We have also legislated targets to reduce net emissions below 2005 levels by 50 per cent by 2030 and 70 per cent by 2035.

But based on the most recent projections from the NSW Department of Climate Change, Energy, the Environment, and Water (DCCEEW), we are not on track to meet any of these targets. Without more effort, we will undershoot the 2030 target by around 9 Mt CO_2-e and the 2035 target by 8 Mt CO_2-e. By 2050, DCCEEW projects our economy will still be emitting about 25 Mt CO_2-e per year – far from a net zero outcome.

Figure 1: The 25 Mt shortfall to the 2050 net zero target

Yearly NSW greenhouse gas emissions, in millions of tonnes of CO_2 equivalent (Mt CO_2-e)



Source: (DCCEEW, 2024).

Without an economy-wide price on emissions, the State is operating firmly in the world of second-best policy. Our first paper proposed that policies to accelerate decarbonisation should follow several principles:

1. Preference should be given to carbon pricing policies that replicate the Commonwealth Safeguard Mechanism, including the ability to use offsets under the ACCU scheme.
2. Should governments not proceed with emissions pricing, we should carry out best-practice cost-benefit analyses on policies that either directly or indirectly reduce emissions. Economic evaluations should use current carbon values (NSW Treasury, 2024) and carefully assess any risk of unintended consequences.
3. Interventions should be technologically agnostic and competitively neutral.
4. Policy overlap should be avoided, except where policies are complementary.
5. Whether the Commonwealth or NSW Government leads on reducing emissions by sector and/or source depends on what jurisdiction is best placed to apply cost-effective policy.

In our paper, we applied these principles to electricity generation. We identified further management of the demand side through digital technologies and cost-reflective pricing to lower the cost of the net zero transition in that sector.

In this paper we apply these principles to:

- residential, commercial, and industrial buildings
- manufacturing and construction
- mining
- waste.

1.2 Existing solutions to help us hit our targets

Australian governments have several tools to send signals to households and businesses that they should reduce their emissions. Between Commonwealth schemes and State powers, striking a balance between interventions is invaluable to helping drive a cost-effective transition to net zero. This section will discuss several such policy interventions.

A broader Commonwealth Safeguard Mechanism

The Commonwealth Safeguard Mechanism builds upon the National Greenhouse and Energy Reporting Scheme (NGERS), established by the *National Greenhouse and Energy Reporting Act 2007* (Commonwealth). The Clean Energy Regulator (CER) collects energy demand and emissions data from businesses and administers the National Greenhouse and Energy Register (NGER) and the Safeguard Mechanism.

The Safeguard Mechanism is a set of rules for large facilities emitting over 100,000 tonnes of CO_2-e per year. It includes transport, industrial (particularly mining), and waste facilities. The Mechanism imposes baselines, or limits, on the emissions of complying facilities; these decline gradually over time. The electricity sector is covered on a sector-wide, rather than facility-level, basis. Its baseline is currently set at 198 Mt CO_2-e per year (CER, 2024c).

Currently, baselines are falling by 4.9 per cent each year. After 2030, the decline rates will be set in five-year blocks. Facilities that emit below their baseline in any year accumulate Safeguard Mechanism Certificates (SMCs). Facilities that emit above their baselines must do one, or a combination, of the following:

- surrender SMCs they have accumulated in previous years
- purchase and surrender SMCs from other facilities
- purchase and surrender offsets under the Australian Carbon Credit Units (ACCU) Scheme
- apply for their baseline to be adjusted upward based on exposure to international trade
- apply to borrow their baseline from the following year
- apply for a multi-year monitoring period.

Trade of SMCs and ACCUs through the Safeguard Mechanism generates an effective carbon price for part of Australia's economy. The price is determined by the business with the highest marginal abatement cost, as it will bid for credits until the price is equal to its marginal cost of reducing emissions.

Most emissions from the sectors discussed in this paper are reported to the CER, published in the NGER database, and covered by the Safeguard Mechanism. In FY22-23 the Mechanism covered 219 facilities, emitting 138.7 Mt CO_2-e, or around a third of Australia's total emissions. When including the electricity sector, around 65 per cent of Australia's emissions are covered.

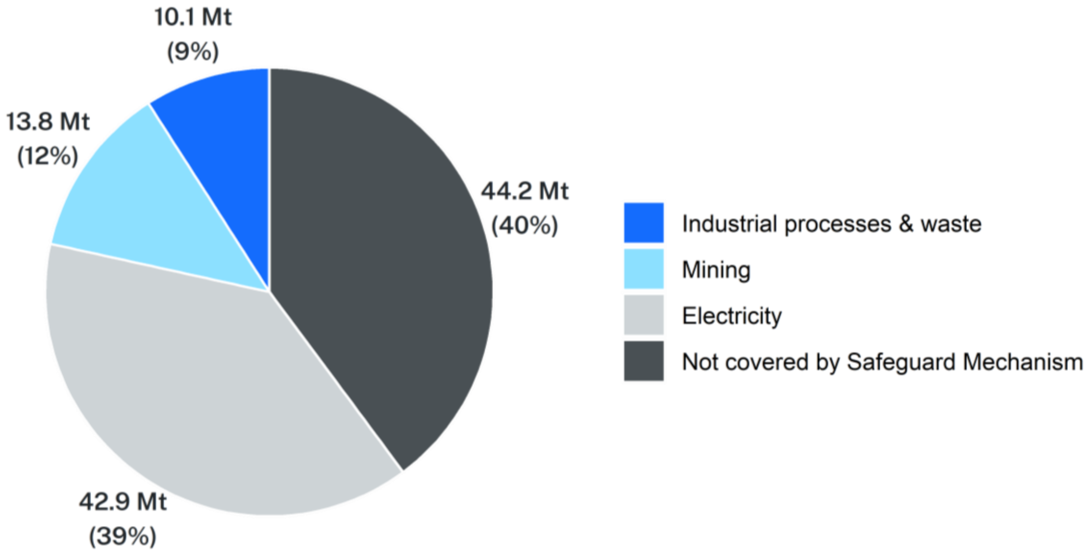
Of the 219 individually regulated Safeguard facilities in Australia, 35 are in New South Wales. These 35 facilities produce roughly 23.9 Mt CO_2-e, or around 20 per cent, of the state's total emissions.

Of the 573 electricity generation facilities covered under the electricity sector baseline as of FY22-23, 90 are in New South Wales and produce 43.7 Mt CO_2-e – about 40 per cent of total NSW emissions. When electricity generation is included, the Safeguard Mechanism covers about 60 per cent of all NSW emissions.

Figure 2 illustrates the breakdown by sector.

Figure 2: Commonwealth Safeguard Mechanism coverage of NSW emissions

Total emissions, by sector (Mt CO2-e), 2022-23



Note: Electricity generation emissions in this chart are slightly different to reported baseline figure due to different calculation approach.
Source: (DCCEEW, 2024), (CER, 2024a).

The Commonwealth Safeguard Mechanism's current approach to decarbonising the electricity sector is ineffectual. It provides no incentive for generators either to reduce their emissions or to replace their capacity with renewables.

In FY22-23 the Australian electricity sector emitted 142 Mt CO_2-e, while the current sectoral baseline imposed by the Safeguard Mechanism is 198 Mt CO_2-e. So the Mechanism's non-binding baseline allows the electricity sector to emit greenhouse gases largely unimpeded by any requirement to decarbonise or to purchase carbon credits. This is unlike the treatment of non-electricity facilities covered by the Mechanism. By 2030, using the current baseline decline rate of 4.9 per cent a year (CER, 2024c) and expected generator closure dates (AEMO, 2024d), the baseline will be 139 Mt CO_2-e but emissions will be just 100 Mt CO_2-e. The baseline is expected to remain well above actual usage right out to 2050, unless government imposes a much more aggressive baseline decline rate beyond 2030.

Detailed information of facilities outside of the electricity system but within New South Wales and covered by the Safeguard Mechanism is available in Appendix A.

In its five-year Productivity Inquiry (2023a), the Commonwealth Productivity Commission recommended expanding the Safeguard Mechanism to make it Australia's main emissions reduction mechanism. Beyond changes already enacted in 2023, it proposed:

1. Redefining baselines in absolute emissions terms rather than emissions intensity terms.
2. Expanding coverage by reducing the facility threshold from 100,000 to 25,000 tonnes CO_2-e emissions per year.

3. Imposing baselines on individual electricity generation facilities, not at the sectoral level or, at a minimum, removing the headroom between current emissions and the electricity sector baseline.
4. Widening transport sector coverage to include liquid fuel wholesalers, with downstream vehicle emissions imputed to them.
5. Giving no additional protection to emissions-intensive trade-exposed industries.

Implementing these additional measures would put large and small emitters on a more level playing field. Using the most recent emissions accounts data and the corresponding NGERs data for 2021-22, the number of Safeguard facilities in New South Wales would increase by 110. This would cover — at facility-level, including electricity — more than 65 per cent of the state's emissions. The reforms would more widely spread the burden of emissions abatement across similar activities, allowing for lower economy-wide costs.

Taking the Commonwealth Safeguard Mechanism further and imputing all transport emissions would increase coverage to around 80 per cent, largely a result of including light- and heavy-vehicle emissions. This would significantly improve the efficiency of the net zero transition.

Table 1: Lowering the Safeguard threshold will spread the responsibility for reducing emissions

Commonwealth Safeguard Mechanism coverage in New South Wales by threshold and ANZSIC division, 2021-22

ANZSIC division	Current Safeguard threshold 100,000 t CO_2-e			Lower Safeguard threshold to 25,000 t CO_2-e			Lower Safeguard threshold to 10,000 t CO_2-e		
	Facilities	Emissions (tonnes)	Sector coverage (per cent)	Facilities	Emissions (tonnes)	Sector coverage (per cent)	Facilities	Emissions (tonnes)	Sector coverage (per cent)
Gas, water, and waste services	5	738,000	15	17	1,632,000	34	35	1,912,000	40
Manufacturing and construction	5	9,976,000	54	28	11,542,000	63	69	12,190,000	66
Primary industries	29	12,889,000	56	41	13,240,000	58	64	13,600,000	59
Transport, postal, warehousing, and commercial services	1	120,000	1	24	2,302,000	18	48	2,680,000	21
Electricity generation	92	43,659,000	100	92	43,659,000	100	92	43,659,000	100
Total	132	67,382,000	61	202	72,375,000	65	308	74,041,000	67

Note: Total may not add up because ANZSIC groupings have been rounded to the nearest 1,000. Primary industries include: mining; agriculture, forestry, and fishing. Commercial services include: accommodation and food services; administrative and support services; education and training; financial and insurance services; health care and social assistance; information media and telecommunications; other services; professional, scientific and technical services; public administration and safety; rental, hiring and real estate services; wholesale and retail trade.

Source: (CER, 2024b).

Pricing emissions at the state-level through load-based licensing

Should the Commonwealth Government decide not to further reform the Safeguard Mechanism, we have state-based options to expand emissions pricing in New South Wales.

The NSW Environment Protection Authority (EPA) administers the *Protection of the Environment Operations Act 1997* (NSW). This legislation grants it the power to set limits on the pollutant loads emitted by holders of environment protection licences. This links licence fees to the quantity of pollutants emitted, consistent with the 'impactor pays' principle.

The EPA's *Climate Change Action Plan 2023-26* (EPA, 2023) identifies a market-based mechanism as an efficient way to reduce emissions. The EPA has the ability through its load-based licensing scheme to cap and reduce greenhouse gas emissions from regulated facilities.

Load-based licensing of smaller emitting facilities would allow the EPA to set emissions baselines and reduce them over time in a manner complementary to, not duplicative of, the Safeguard Mechanism. Some elements would be identical. For example, the EPA could allow facilities that emit below their limits to sell excess emissions credits to emitters that exceed their limits. Other recognised, Australian, carbon credits such as ACCUs or SMCs could be surrendered in place of any EPA-specific credits when a regulated facility exceeds its emissions limit. To avoid double-counting of abatement, this would be subject to those same ACCUs and SMCs not already surrendered under the Safeguard Mechanism. This would support a least-cost approach to emissions reduction.

Solving incentive problems and information failures

Incentive problems can occur when individuals or organisations do not benefit from reducing their emissions, even if it is cost-effective to do so. For example, a residential landlord might not have incentive to insulate and electrify its property because the benefits of lower energy costs flow to tenants. Prospective tenants might be willing to pay higher rents if future energy costs of a property are lower, but this information might not be known when leases are signed. Addressing this challenge requires policy that aligns economic incentives with our climate change objectives.

When people or organisations lack adequate knowledge about the costs and benefits of an option, decision-making can be less efficient. The options to address information failures can range from light-touch public awareness campaigns to mandates for information-sharing and transparency.

Planning system processes

The net zero transition can also be supported through the land use planning system. The *Environmental Planning and Assessment Act 1979* (NSW) allows development controls to incorporate environment standards. These can include minimum levels of energy efficiency and restrictions on use of fossil fuels. Where appropriate, these requirements can be embedded into the development approval process. This can generate resource savings by avoiding the need for costly retrofitting later.

In May 2024, the NSW Minister for Climate Change, Energy, and the Environment wrote to the Minister for Planning about the *Climate Change (Net Zero Future) Act 2023* (NSW). The Minister advised the 2024 emissions projections found the state is not on track to meet its 2030 and 2035 targets without further action by government and the private sector. The letter further advised updates to NSW Government climate change policy that have implications for current and future planning decisions:

- All sectors need to ratchet down their emissions to meet legislated targets.
- Those involved in assessment and decision-making processes — including the NSW Department of Planning, Housing, and Infrastructure (DPHI) and the Independent Planning Commission — should have regard to:
    - the state's emissions reduction targets
    - to the extent relevant, the Climate Change Act's guiding principles.
- The EPA's Climate Change Assessment Requirements (NSW EPA, 2024) and Guide for Large Emitters (NSW EPA, 2024) must be taken into consideration by proponents as part of the planning assessment process.

In June 2024, the Minister for Planning wrote to the Chair of the Independent Planning Commission directing the Commission to have regard to the policy changes arising from Minister Sharpe's letter (Scully, 2024).

The draft assessment requirements apply to projects that are likely to emit 25,000 tonnes CO2-e or more of scope 1 and 2 emissions in any financial year. Proponents must carry out a greenhouse gas assessment and prepare a mitigation plan for scope 1, 2, and 3 emissions.

Coal mining and gas projects also require Commonwealth approvals under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) to ensure they do not pose signifcant risks to water resources. Tightening approval thresholds or adding climate change as a matter of national environmental significance are ways to take account of emissions reduction targets in prospective mine operations.

2 Buildings

2.1 Overview

We burn fossil fuels to heat our homes and workplaces (including water systems) and to cook our food. These activities create most of our stationary energy emissions from buildings. The gas used in these activities accounted for 4.1 Mt CO_2-e of emissions in 2021-22.[3] (Homes and businesses also use electricity to cook and heat – we discussed abatement of electricity emissions in our first paper.)

The Commonwealth Safeguard Mechanism does not currently cover any residential, commercial, or industrial buildings in New South Wales. The Commonwealth Productivity Commission has recommended that the Australian Government lower the compliance threshold to 25,000 tonnes CO_2-e per year. But even this would still not affect any residential or commercial buildings.

We will need other levers to drive decarbonisation. Regardless of whether pricing or regulatory incentives are used, achieving net zero in the state's building stock will require a combination of:

- energy efficiency upgrades, including insulation
- electrification of existing premises that currently have gas connections
- uptake of consumer energy resources, including rooftop solar and distributed batteries
- faster uptake of smart meters and more cost-reflective electricity pricing
- implementing smart-grid digital technologies, including demand response and virtual power plants
- upgrading electricity grid infrastructure, including transformers, substations, and distribution lines in areas at risk of congestion
- avoiding future connections to the gas network.

Getting our buildings off gas will have a second-round benefit for our pursuit of net zero. Lower gas demand for stationary energy uses will conserve stocks to support strategic needs, particularly gas-fired power generation to firm renewables in the electricity system.

Box 1: Circular economy principles in the construction industry

In the construction sector, 'embedded emissions' are the carbon emissions required to manufacture, transport, and install building materials like concrete, steel, glass etc. Producing construction materials requires a large amount of energy. And some materials, such as cement and steel, also have intrinsic emissions from chemical

[3] Figure includes bottled gas.

processes in their manufacturing. By 2050 embedded emissions could make up 85 per cent of the carbon in the Australian construction sector (Dalton, et al., 2023).

To avoid double-counting, we do not address embedded emissions directly in this paper. Embedded emissions are generally accounted for as manufacturing, mining, transport, or waste emissions. However, thinking about embedded emissions helps us visualise the end-user 'demand' for carbon-intensive materials. Currently the Australian construction industry relies heavily on virgin construction materials. Moving to a more circular-economy approach — one that encourages the reuse of materials — might lead to much lower overall emissions than use of entirely new materials.

The Australian Housing and Urban Research Institute has identified a range of opportunities to improve coordination and capacity in the sector to increase uptake of circular-economy approaches. Examples include regulatory interventions and capacity-building (Dalton, et al., 2023). However, as we discuss in Chapter 5, circular-economy approaches should only be pursued where they demonstrate net economic benefit.

2.2 Decarbonising buildings

Electricity system emissions will descend toward net zero well in advance of 2050. Wherever we can replace burning gas with electricity, electrification is a logical route to decarbonise buildings. Conversely, failure to phase out gas appliances jeopardises the goal of net zero emissions by 2050 (Wood, Reeve, and Suckling, 2023).

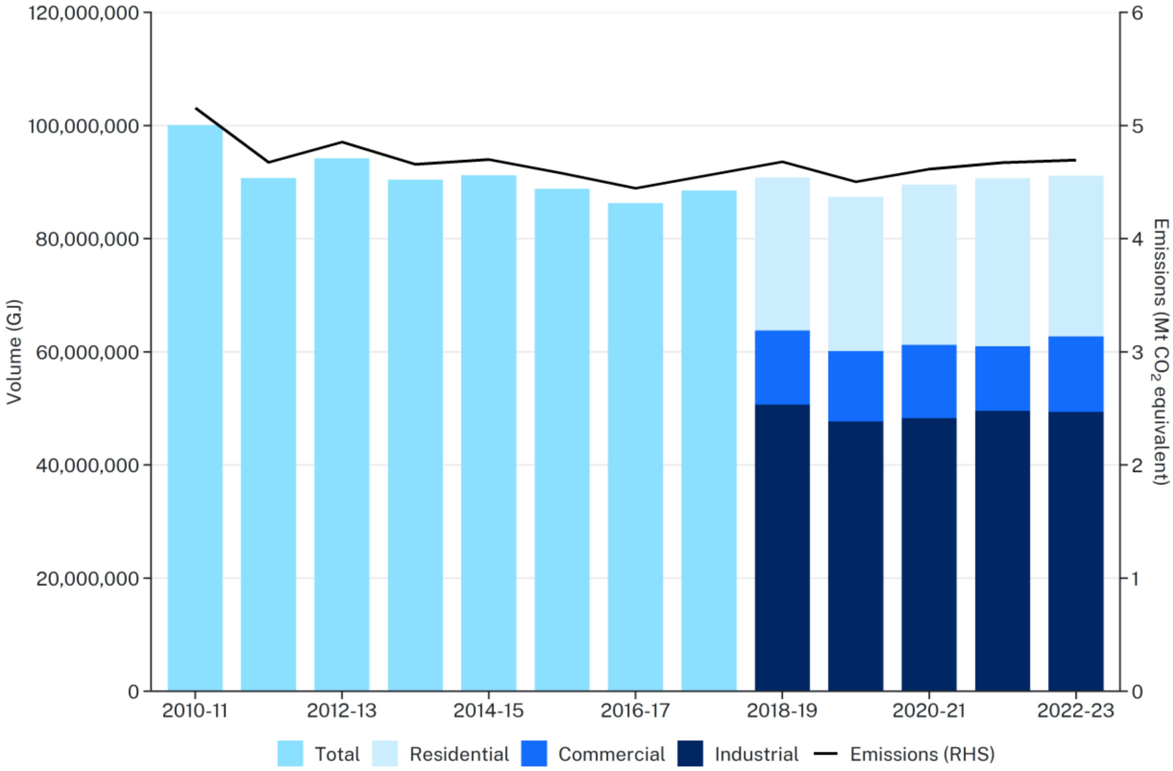
Residential and commercial buildings in New South Wales consumed more than 41.7 million gigajoules (GJ) of natural gas in 2022-23.[4] That was around 46 per cent of total gas consumption.

Figure 3 shows that this level has been largely unchanged since 2011. Improvements in the energy efficiency of gas appliances has been offset by increased demand from additional connections to the gas network. Gas consumption in buildings has been flat and is currently just a small proportion of stationary energy emissions. But allowing new connections will only impose costs to decarbonise later.

[4] New South Wales here includes only the customers connected to the Jemena distribution network. It excludes some townships such as Albury which are connected to the gas networks of neighbouring states, and those on bottled gas connections.

Figure 3: Gas consumption in New South Wales has been steady for the past five years

Jemena distribution network gas volumes by customer type, 2011-23



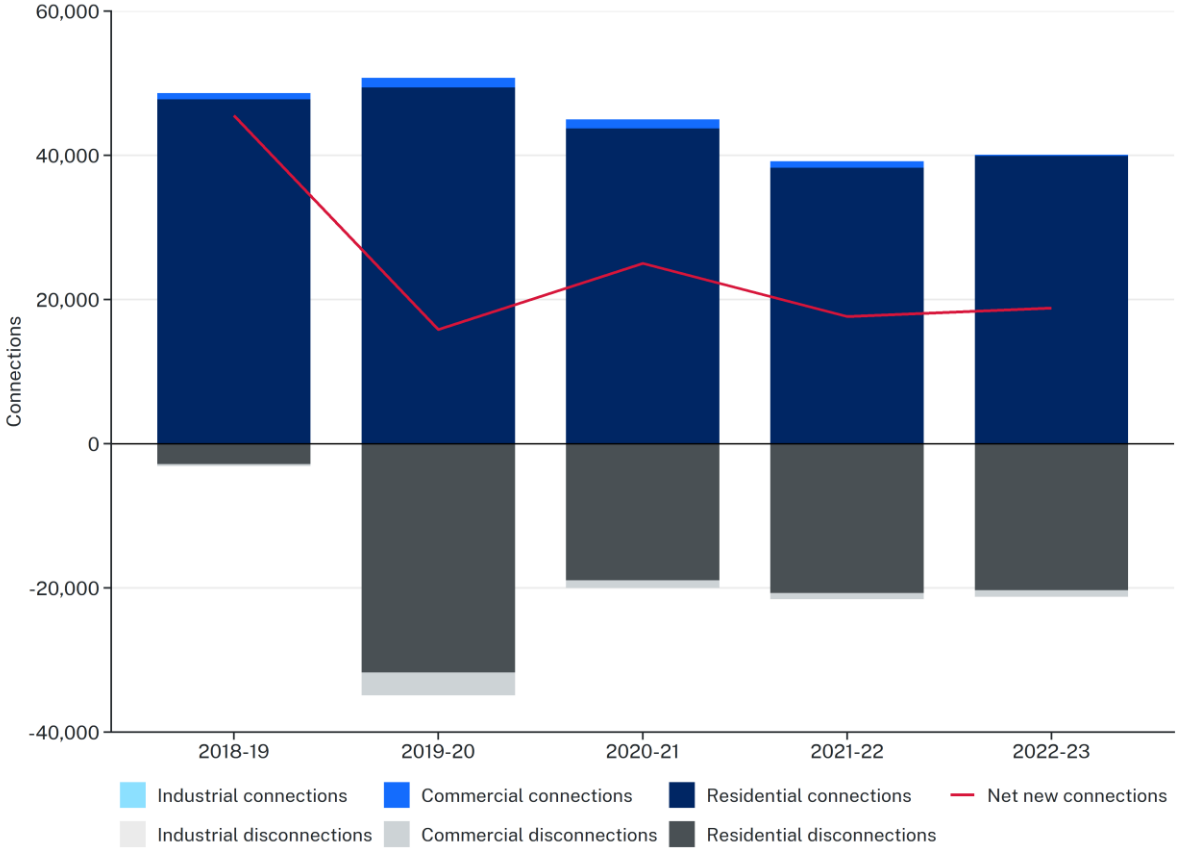
Note: This figure excludes bottled gas consumption.
Source: (AER, 2024a).

In short, the more connections that are made to the gas network (Figure 4), the greater the cost will be to decarbonise later.

The obvious route, therefore, is for existing buildings to turn off their gas connections and for new buildings not to be connected at all. The private benefits of this are significant, as electricity is cheaper and healthier. Electrification will have significant benefits for economically disadvantaged groups. These groups tend to spend a higher proportion of their income on utilities while having have less efficient appliances and home insulation. Electrification will allow them to access cheaper energy and have reduced levels of indoor air pollution. Retrofitting costs, however, are also high. And the scale of this task accentuates the challenge; presently, there are 1.5 million gas connections in New South Wales. This, in part, explains why progress has been slow.

Figure 4: More households are joining the gas network than leaving

Jemena gas distribution network customer connections and disconnections, 2019-23



Note: 'Connections' are the new premises or facilities joined to the Jemena network, while 'disconnections' are facilities removed from the network. Industrial connections range from one to 12 and disconnections from five to 15 each year for a net of seven disconnections from 2018-2023.
Source: (AER, 2024a).

An alternative to electrification is to replace natural gas with green hydrogen. But this is unlikely to cut emissions effectively. Current natural gas distribution networks and appliances will need substantial and expensive retrofitting to manage pure hydrogen.

A US study found that networks there could operate safely with a mix of around 20 per cent hydrogen and 80 per cent natural gas (Melaina, Sozinova, & Penev, 2013). If adopted for the Australian east coast distribution network, this would reduce emissions by only around six per cent (NREL, 2022). Similar results have been observed in the UK and Germany (Linke, 2024). Moreover, burning hydrogen and natural gas blends does not necessary reduce potential health impacts from gas appliances. Examples include asthma, which can arise from particulate matter and nitrogen oxides (Wood, Reeve, & Suckling, 2023).

Moving to a fully hydrogen-based distribution system would require replacing many gas appliances. Without innovation in hydrogen appliances that drives a substantial reduction in costs, electrification will be the cost-effective option for residential and business uses. This advantage is accentuated by the much lower cost of renewables-generated electricity compared to green hydrogen.

2.3 Policy options to achieve net zero buildings

The Energy Savings Scheme (ESS) certificate program in New South Wales is an existing framework to incentivise electrification. It allows households and businesses to earn certificates for installing energy saving upgrades, such as high-efficiency pool pumps, LED lighting, and more efficient hot water systems. Their upfront costs are reduced when certificates are purchased by energy market participants to meet legislated energy saving targets.

Opportunities exist to expand the ESS and drive continued growth in energy efficiency in New South Wales. For households, the ESS could include other common, energy-hungry appliances such as refrigerators, ovens, washing machines, and dryers. Broadening the range of improvements eligible under the Scheme could capture more, relatively low-cost abatement opportunities. This could allow for more ambitious energy savings targets than currently legislated.

Land and Housing Corporation units must be funded to improve energy efficiency, electrify, and remove gas appliances. This would allow social housing tenants to benefit from lower energy costs and improved health outcomes from cleaner indoor air. Consideration could also be given to subsidising community housing providers to electrify and insulate their housing portfolios.

Regulatory interventions, complementary to the ESS, that could accelerate the energy transition of homes and business premises include:

- ending **new gas connections** to homes and businesses
- **stronger messaging** about the bill savings and health benefits of moving away from gas appliances
- **minimum rental standards** that set dates for landlords to insulate and electrify tenanted properties
- progressively **increasing minimum energy efficiency standards** and improved disclosure of building energy performance under the Sustainable Buildings SEPP.

Other Australian and international jurisdictions have, or are considering, bans on new gas connections to reduce carbon emissions from gas appliances (Box 2).

Box 2: Ending gas connections

Local government has a significant role in the planning system pursuant to the *Environmental Planning and Assessment Act 1979* (NSW). Among other functions, councils publish development control plans (DCPs), which influence the nature of development. Several NSW councils have either banned new gas connections or signalled a desire to do so through their DCPs.

There are, however, limitations on this power. Under chapter 2.2 of the *State Environmental Planning Policy (Sustainable Buildings) 2022* (NSW Government, 2022), councils are prevented from banning new gas connections if the purpose is to reduce emissions. Councils have instead relied on health and financial grounds for their bans.

Table 2: Status of gas connection bans in NSW LGAs

Jurisdiction	Residential	Commercial	Stage	Application
Canada Bay	Yes	Yes	Exploring	Entire LGA
Canterbury-Bankstown	Yes	Yes	Exploring	Precinct-based
Inner West	Indoors only	No	Exploring	Entire LGA
Lane Cove	Yes	Yes	Implemented	Entire LGA
Newcastle	Indoors only	No	Exploring	Entire LGA
Parramatta	Yes	Yes	Implemented	Precinct-based
Ryde	Yes	No	Exploring	Entire LGA
Sydney City	Yes	Yes	Exploring	Entire LGA
Waverley	Yes	No	Implemented	Entire LGA
Woollahra	Indoors only	No	Exploring	Entire LGA

Other jurisdictions are phasing out gas more actively. The Australian Capital Territory has banned new gas connections. Internationally, The Netherlands banned new gas connections in 2018, and Germany will end the sale of new gas boilers by 2028. The European Union has agreed rules that prohibit new buildings from creating emissions from fossil fuels by 2030. It will also ban fossil fuel (excluding hybrid) boilers by 2040.

The national Commercial Building Disclosure (CBD) Program aims to improve the efficiency of large office buildings across Australia. It is mandatory for commercial office spaces over 1000 m^2 and optional for all other buildings. Since 2011 the program has supported a 40 per cent reduction in the energy intensity of covered buildings by incentivising operational changes and end-of-life capital upgrades (KPMG, 2024).

An expansion of the CBD Program — or application of a state equivalent — to shopping centres, hotels, data centres, and hospitals would be an effective way to encourage improvements in energy efficiency. The Australian Energy Regulator finds this approach could cover over eight million MWh of energy consumption, or roughly 10 per cent of total NSW electricity consumption (AER, 2024b). Coupled with a progressive ratcheting up of energy efficiency standards, this approach would accelerate decarbonisation of commercial and industrial buildings. Improved energy efficiency of this scale would also moderate electricity demand, smoothing the transition to utility-scale renewables and storage.

An alternative would be to apply load-based licensing to commercial and industrial buildings above a certain threshold, e.g. 10,000 tonnes CO_2-e, as discussed in Box 3.

Box 3: Load-based licensing can be used to drive down emissions from large commercial and industrial buildings

In total, New South Wales generates 1.7 Mt CO_2-e emissions from around 110 facilities that emit between 10,000 and 25,000 tonnes of scope 1 emissions. These same facilities also account for 4.6 Mt CO_2-e of scope 2 emissions, mainly from the fossil fuel-powered electricity that they consume.

The EPA's load-based licensing scheme could be used to help drive emissions from these facilities towards net zero by requiring them to pay a licence fee based on their volume of emissions. Many of these facilities are in industrial sub-sectors, including cement manufacturing, food processing, and warehousing. Here, technologies to decarbonise are available and could be more readily induced by an emissions licensing fee rather than energy efficiency certificates and other subsidies.

The alternative is to allow these facilities to decarbonise at their own pace without any clear market signals to guide their investment decisions. This risks, however, contributing to significant residual emissions in 2050. (The 'current policy – abatement as tracking' scenario found stationary energy would be the second-largest sources of emissions by mid-century.)

2.4 Coordination of household energy generation, storage, and demand

Transitioning buildings to energy efficient, all-electric premises can reduce emissions *and* deliver cost savings for property owners. Consumer energy resources (CER) are energy generation systems 'behind the meter' in homes or businesses. They are most commonly rooftop solar panels but can also be battery storage, wind generating units, and even electric vehicles (EVs) (Box 4).

The Australian Energy Market Commission (AEMC) and Australian Energy Market Operator (AEMO) are designing and implementing market reforms to unlock consumer energy resource generation. Virtual power plants (VPPs), where consumer energy resources are digitally aggregated and coordinated to supply the National Electricity Market (NEM), are in their infancy, as discussed in our first paper. As more technologies and consumers join, VPP arrangements may become more complex and consumer protections need to keep up. Work is also progressing with distribution network service providers to ensure energy infrastructure can accommodate two-way electricity flow.

Box 4: Electric vehicles and energy demand from buildings

EVs have potential to support emissions reductions beyond the transport sector. Both electricity demand and road usage peak during the 6-9am morning peak and in the late afternoon/evening. Outside of these periods, EV batteries can be used for backup energy storage for households and some businesses. They can charge during periods of low demand relative to high supply (e.g. during the day amid abundant solar power generation). They can then discharge power into the grid at times of high demand, especially in the evening. This would further smooth energy consumption during the peak and alleviate pressure on the grid.

The NSW Consumer Energy Strategy is the NSW Government's plan to help households and businesses benefit from the renewable energy transition. The Strategy has a range of components, including:

- social housing energy efficiency improvements
- home battery incentives
- appliance upgrade assistance
- support for apartment residents to invest in solar systems.

Together these components increase access to high-efficiency appliances and reduce reliance on the electricity grid, essential policies that help moderate demand for energy as we transition. Further reforms to help manage demand, such as increasing the use of cost-reflective pricing and broadening the Energy Savings Scheme, could build on the benefits of the Strategy.

2.5 Construction industry capacity to achieve net zero buildings

Australia is currently experiencing a boom in construction activity fuelled by record levels of public infrastructure investment. Delivering on the ambitious National Housing Accord and the net zero energy transition is likely to stretch the construction sector beyond capacity. Resource constraints are a major risk to delivery of low-emissions developments and the timely retrofitting of existing buildings.

AEMO's *Integrated System Plan* (2024a) estimated that up to 60,000 skilled workers will be needed nationwide per year to build and maintain the energy infrastructure needed to decarbonise the NEM. Electricians make up a large proportion of that workforce. But the same workforce is also needed to decarbonise our building stock and support delivery of public infrastructure and private development projects. New South Wales needs to take action to secure a reliable supply of construction-sector workers, across all qualifications and skill levels.

Supply chain constraints and the availability of capital availability will also impact the speed of our efforts to decarbonise the state's building stock. The NSW economy is competing domestically and internationally for wiring, appliances, insulation, windows, and other materials essential to the net zero transition for buildings. Access to these inputs will determine whether our legislated emissions reduction targets can be met.

3 Manufacturing and construction

3.1 Overview

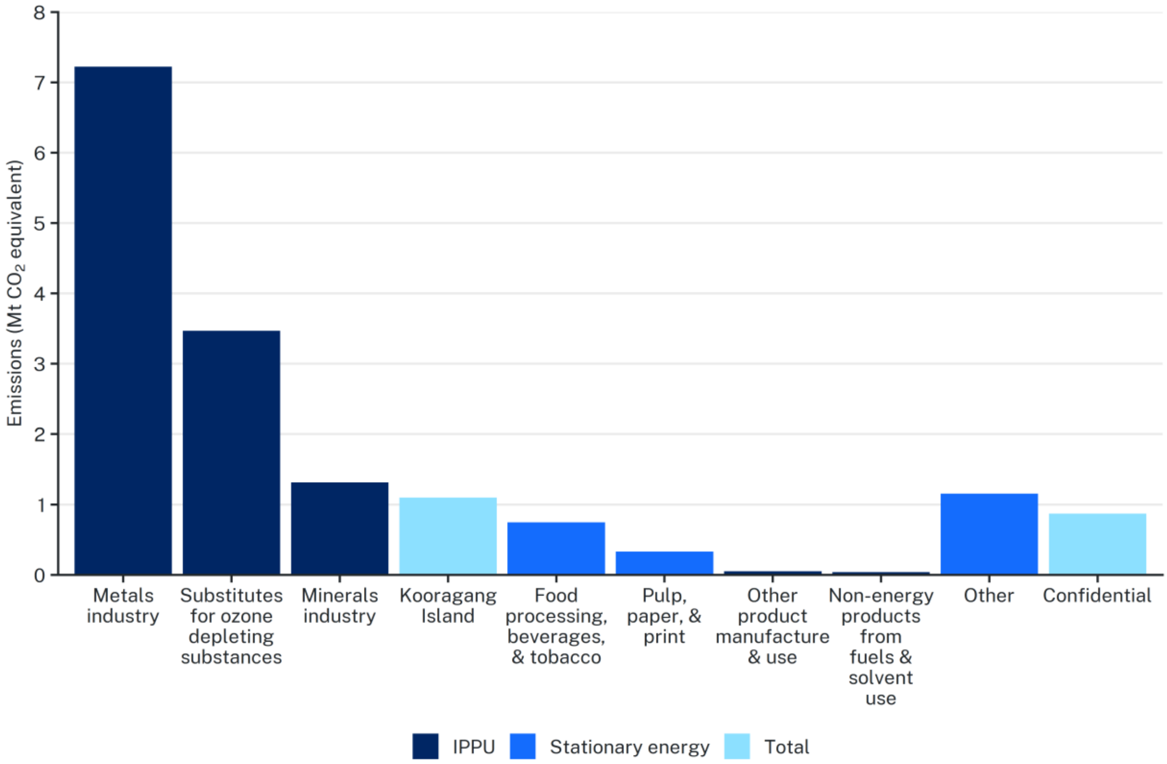
Manufacturing and construction emissions come from two sources — stationary energy and industrial processes and product use.

- **Stationary energy** covers the combustion of fossil fuels for energy purposes in manufacturing. Manufacturing is the largest producer of stationary energy emissions, accounting for around 4.2 Mt CO_2-e emissions in 2021-22.
- **Industrial processes and product use (IPPU)** covers greenhouse gas emissions from industrial processes, the uses of gases in products, and non-energy uses of fossil fuels. In 2021-22, they accounted for 12.7 Mt CO_2-e of emissions.

  Decarbonisation of IPPU will be relatively slow under the 'current policy – abatement as tracking' scenario. From 11.0 Mt CO_2-e by 2030, emissions are projected to fall to 9.4 Mt CO_2-e by 2035 and 3.8 Mt CO_2-e by 2050.

Figure 5: Manufacturing contributes significantly to total NSW emissions

Manufacturing emissions by activity, 2021–22



Source: (DCCEEW (Commonwealth), 2024), (CER, 2024a), NSW P&EC calculations.

Manufacturing emissions in New South Wales are heavily concentrated in the production of metals and substitutes for ozone depleting substances. Alone, these activities are responsible for over two thirds of total sector emissions.

Conventional steelmaking uses a blast furnace to convert coking coal, iron ore, and limestone into metallic iron. This process produces significant CO_2 emissions.

Substitutes for ozone depleting substances are synthetic greenhouse gases that began replacing chlorofluorocarbons (CFCs) from the early 1990s to help protect the ozone layer. The most common are hydrofluorocarbons (HFCs). Unfortunately, these gases have very high global warming potentials. Moreover, they are widely used in air conditioning, refrigeration systems, fire protection, and even as by-products of aluminium manufacturing (DCCEEW (Commonwealth), 2024).

From 2018 Australia began phasing out the use of HFCs, limiting how much can be imported, and encouraging a switch to alternatives with lower warming potentials. Synthetic greenhouse gas emissions from aluminium manufacturing, namely perfluorocarbons (PFCs), can be reduced with new technologies such as point feeding alumina and prebaking of anodes. This can be complemented by process improvements that maintain optimal conditions for avoiding PFC emissions.

The chemicals industry includes the production of ammonia, fertilisers, and commercial explosives. Ammonia, the most readily produced of these three, is an input to ammonium nitrate and urea, which are then used to manufacture commercial explosives and fertilisers.

3.2 Decarbonising manufacturing

Technologies for reducing emissions

Several avenues can be pursued to decarbonise manufacturing:

- **Energy efficiency** improvements that reduce fossil fuels combustion can abate stationary energy emissions. Examples include insulation and heat exchangers.
- **Electrification** can abate stationary energy emissions where low- or zero-emissions electricity replaces fossil fuels. Recent estimates suggest almost half the fuel used for industrial energy can be electrified with available technologies (Roelofsen, Somers, Speelman, & Witteveen, 2020). But challenges remain where high-heat processes can only be achieved by burning fossil fuels.
- **Process changes** such as changing production technology, changing inputs, or better managing by-products can significantly reduce manufacturing emissions in certain industries.
- **Green hydrogen** is produced via electrolysis of water, which uses electricity generated from renewables to split the hydrogen and oxygen, with the hydrogen then stored. The cost of renewable energy and electrolysers will determine green hydrogen prices.

- **Carbon capture and storage** (CCS) involves collecting carbon emissions from industrial processes before it enters the biosphere, and then storing it (for example, underground). CCS might be useful to manage emissions that cannot be addressed through electrification, such as in the cement industry. This seems an unlikely solution, however, without some combination of a high carbon price and innovations that significantly moderate costs.

For much of manufacturing, the pathway to net zero is certain to include electrification. Lower variable costs relative to fossil fuels can help overcome higher capital costs of retrofitting and replacing plant and equipment.

The fastest possible transition of the electricity system to firmed renewables is therefore central to the energy transition in manufacturing and construction. Electrification of sectors currently reliant on fossil fuels is a key driver of the substantial increases in electricity demand under AEMO's energy market scenarios.

Other technologies have a range of potential in domestic and international markets.

Green hydrogen

Green hydrogen has many possible applications as an intermediate and final good:

- in existing manufacturing industries, including aluminium, ammonia (including green ammonia), cement, and steel
- as a zero-emissions fuel for some aviation and heavy vehicle purposes
- to firm renewable energy sources like wind and solar
- as an input to precision fermentation in food production
- as a potential export item, either as hydrogen or transformed into green ammonia.

Green hydrogen's cost relies on two key drivers:

1. It uses costly electrolysers to split water into oxygen and hydrogen. New South Wales should benefit from improvements in economies of scale in the manufacture of electrolysers over time, as we have with solar panels (CSIRO, 2024).
2. It uses electricity to power the electrolysers. As more renewable energy generation enters the grid, the marginal cost of electricity is expected to fall, moderating the cost of green hydrogen production.

Together these factors should eventually lead to uptake of green hydrogen. But this could be contingent on wider adoption of carbon pricing across the economy and more ambitious emissions reduction trajectories.

The NSW Government has adopted a hydrogen strategy to reduce green hydrogen's cost and increase its production. The strategy includes:

- electricity concessions to reduce variable costs
- 'hydrogen hubs' to co-locate green hydrogen producers and consumers
- support for a hydrogen refuelling network for heavy vehicles.

Green hydrogen's potential should be neither overstated nor understated. Policy should not distort the market such that 'green' hydrogen is prioritised over other zero-emissions technologies. One example here is the push for hydrogen-fuelled light vehicles, which no longer appear to be the optimal net zero pathway in transport. Battery technology improvements are proving to be more cost-effective here. Where such multiple decarbonisation pathways exist, policy should be technologically agnostic.

For industry to adopt green hydrogen in hard-to-abate sectors, it must become more cost-effective than fossil fuels. Currently, most of the hydrogen used is in industrial contexts and is ‘grey’. Grey hydrogen is produced by reacting natural gas with steam, which produces CO_2 as a by-product. Ideally, these emissions would be priced, nudging producers to transition to zero-emissions production or invest in carbon capture and offsets. Carbon pricing would also incentivise producers to innovate ways to reduce the cost of producing green hydrogen.

Iron and steel

Traditional steel manufacturing produces greenhouse gases in two distinct ways:

- a furnace heats iron ore using fossil fuels
- that hot furnace then smelts iron ore into metallic iron by chemically combining it with coking coal, producing carbon dioxide as a side product.

To make completely zero-emissions steel, we must address both emissions sources. Technologies exist that can achieve this, but they are generally not commercially viable. Most green steelmaking methods are in the research and development or demonstration phases.

Near zero-emissions steel is commercially viable. It can be produced by recycling scrap steel and by using renewable electricity in an electric arc furnace, as GFG Alliance’s Sydney facility does. Recycled steel requires very little, if any, smelting. Steel is already recycled at high rates. Increasing recycling could further reduce emissions in both the manufacturing and mining sectors, subject to the availability of scrap steel.

Other low-emissions steelmaking techniques include using a direct reduction furnace to produce direct reduced iron (DRI) and then an electric arc furnace (EAF) to create steel (DRI-EAF). Renewable electricity can power the EAF. DRI uses natural gas rather than coal to smelt the iron ore, producing emissions that are around two thirds lower than a typical blast furnace. If green hydrogen can replace natural gas in the DRI process, emissions can drop to almost zero. The first commercial green hydrogen steel mill is currently planned for construction in Sweden, to begin production by 2030.

Although technically feasible, zero-emissions DRI-EAF steelmaking faces hurdles to its uptake in Australia. One hurdle is the high cost of green hydrogen. Another is that 95 per cent of iron ore mined in Australia is lower-grade hematite, which (unlike magnetite) is not compatible with current DRI-EAF methods. Researchers are tackling this hurdle. For example, the University of Newcastle was recently granted $2.94 million by the Australian Renewable Energy Agency (ARENA) to further develop the hydrogen DRI-EAF process route for low-grade ore (ARENA, 2024).

Other possible pathways to zero-emissions steelmaking exist. For example, electrolytic steelmaking separates iron ore’s iron and oxygen by heating the ore to 1,600 degrees in a liquid solution, using electricity (Boston Metal, 2024). But this technology is in early development and is not projected to be commercially viable before the 2040s (Horngren, et al., 2023).

Ammonia

Ammonia (NH_3) is one of the most important industrial chemicals we have. It is the basic building block of fertilisers, as well as plastics, explosives, dyes, and fabrics (IEA, 2021). It also has the potential to become a green feedstock and energy carrier in a net zero economy.

Ammonia is produced by extracting nitrogen from the air and combining it with hydrogen at high temperatures and pressures. This process uses a great deal of energy, but it can be done using zero-emissions electricity.

Green ammonia manufactured from green hydrogen and renewable energy at domestic facilities is clearly a promising technology for the NSW mining, agriculture, food, and health industries. It has an advantage over green hydrogen in transporting zero-emissions energy. For its weight, ammonia carries more energy than pure hydrogen. It turns from gas to liquid at a higher temperature than hydrogen and is at lower risk of leaking from tanks. Ammonia's efficiency advantage widens as the storage duration increases, because keeping hydrogen as a liquid takes so much more energy than keeping ammonia liquid (Muller, Pfeifer, Holtz, & Muller, 2024). The advantage holds for short travel times of around 30 days.

At its destination, ammonia can be used either in industrial processes or as fuel. Alternatively, it can be turned back into hydrogen, which can also be applied to industrial processes and as fuel. Transforming energy from hydrogen to ammonia for transport and back to hydrogen again takes substantial energy. But it could become commercially viable if cheap zero-emissions electricity becomes plentiful.

Moreover, unlike hydrogen, ammonia already has a global infrastructure network to transport it by sea. This network could be expanded to move the larger volumes needed to reach net zero (IRENA, 2023).

Cement, concrete, lime, and plaster

Concrete is one of most important materials in the construction industry. No viable alternative material exists for building office and residential towers, or for transport, civil, or water infrastructure. Meeting Australia's housing and infrastructure needs will require lots of concrete.

Making concrete requires cement. Cement production involves heating limestone to high temperatures in a kiln; at this temperature, a chemical reaction breaks down the limestone's calcium carbonate into calcium oxide and CO_2. Around 50 per cent of emissions from cement production come from this chemical reaction. The rest comes from the stationary energy emissions produced in heating the kiln.

There are several ways to reduce emissions from cement – some combination of these may be needed:

- **Use less cement**: Inputs of cement could be reduced by 15 per cent over the next decade by designing structures more efficiently, utilising higher strength cement, and replacing concrete with timber (Beyond Zero Emissions, 2017).
- **Use lower-emissions ingredients:** Emissions could be reduced by partially substituting clinker, a mix of limestone and aluminosilicate materials, for materials that are less energy intensive to produce and refine. Examples include fly ash, slag, or silica fume (Fischetti, Bockelman, & Srubar, 2023). Australia is estimated to have fly ash[5] supplies that could support 20 years of domestic cement production after all coal power stations close (Beyond Zero Emissions, 2017). The capital cost of this technique could be lower than a standard cement plant because it does not require a kiln to produce clinker. However, this process is yet to be commercially demonstrated and the long-term supply of ash and slag is limited. Researchers are investigating using slag from recycled iron, made in EAFs and from DRI-EAF steel, as an alternative to its other forms.
- **Using waste as an alternative fuel can deliver emissions reductions:** High temperatures in cement kilns can incinerate toxic waste. The resulting ashes could then be incorporated into clinker. Mexican company Cemex derives up to 57 per cent of energy in cement plants from such alternative fuels.
- **Capture carbon from the cement production process:** Given that the intrinsic emissions in the cement production process cannot be avoided, carbon capture and storage may be essential to achieving net zero in this activity. But CCS's high costs may make this difficult to sustain commercially without broader application of carbon pricing.
- **Switch fuels:** Coal burned in cement kilns can be replaced with lower-emissions alternatives such as natural gas, biomethane, and biomass, or with green hydrogen.

Aluminium, food and beverages, and other industries

Aluminium production is Australia's most carbon-intensive industry, producing around 24 per cent of scope 1 industrial emissions (CCA, 2024). It involves two stages: refining and smelting. Refining converts bauxite ore to alumina, contributing around 85 per cent of aluminium production emissions. Smelting alumina into aluminium produces the remaining 15 per cent. As of 2024, New South Wales has no aluminium refineries and just one smelter — the Rio Tinto Tomago facility, Australia's largest.

Aluminium smelting passes an extremely high electrical current through a high temperature liquid to separate alumina into aluminium and oxygen. Generating the required temperatures and electrical current requires enormous amounts of electricity. Traditional smelting methods also use carbon anodes that break down over time, a process that creates CO_2.

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[5] Fly ash is collected as a by-product of burning coal.

Rio Tinto plans to transition its Tomago smelter onto renewable energy contracts, which will significantly reduce its electricity emissions. It also has plans to deploy inert anode technology — currently expensive — to prevent the degradation of carbon anodes and emissions of CO_2 from aluminium smelting.

Manufacturing processes in other industries can be decarbonised through fuel switching for process heat, such as:

- microwave heating for ceramics, brick, chemicals, and timber
- electric resistance for glass and chemicals industries.

Industrial heat pumps could help reduce emissions from textiles, timber, food and beverage, and chemical manufacturing.

Some projects are underway to reduce incidental emissions in other industries. For example, in nitric acid production a process called tertiary catalysis can convert nitrogen oxide greenhouse gases (a waste by-product) to nitrogen and oxygen. Orica's Kooragang Island facility is currently trialling this technology.

The Safeguard Mechanism in the manufacturing sector

The Commonwealth Safeguard Mechanism is the main policy driving emissions reduction in the manufacturing sector. In FY22–23, six facilities were covered by the Mechanism, emitting a total of 10 Mt CO_2-e. This was around 61 per cent of total manufacturing sector emissions.

'Carbon leakage' occurs when a company moves production to a country with less stringent greenhouse gas emission policies, potentially causing global emissions to rise. To help avoid such leakage, the Safeguard Mechanism includes tailored treatment for emissions-intensive, trade-exposed facilities. Manufacturing facilities are eligible for a discounted decline rate on their baselines as low as one per cent each year. But while this provision helps maintain the competitiveness of export industries, it may limit domestic emissions abatement.

This tailored treatment may change depending on the way other jurisdictions interpret the Safeguard Mechanism. Policies such as carbon border adjustment mechanisms may have a greater impact than the tailored treatment on trade-exposed industry. Nonetheless, the Mechanism remains well-placed to drive manufacturing emissions abatement, particularly if carbon pricing in manufacturing is more broadly applied.

The NSW Net Zero Industry and Innovation Investment Plan (NZIIIP)

The NZIIIP falls under the NSW *Net Zero Plan Stage 1: 2020-2030* and commits $360 million to reducing industrial emissions. It aims mostly to raise abatement in high-emitting industries, with $305 million allocated for this. The balance is reserved for clean technology innovation.

These targeted measures can complement the Commonwealth Safeguard Mechanism if they help achieve emissions reductions that otherwise would not have occurred. Whether emissions reduction attributable to the NZIIIP are genuinely additional is, however, difficult to measure. Following the principles for a cost-effective transition —

discussed in our first paper — the NSW Government should assure itself that NZIIIP grants are genuinely complementary to carbon pricing under the Safeguard Mechanism. Best practice cost-benefit analysis is the right evaluation framework for doing so.

Expanding carbon pricing in manufacturing

As discussed, in 2023 the Commonwealth Productivity Commission recommended expansion of the Safeguard Mechanism to make it Australia's principal emissions reduction policy. Adopting its proposal to lower the threshold for complying facilities from 100,000 tonnes to 25,000 tonnes of CO_2-e would allow the Mechanism to cover a further 21 facilities. This would include an additional 1.5 Mt CO_2-e, increasing manufacturing sector emissions coverage from 63 per cent to 70 per cent.[6] Including coke oven gas at BlueScope's Port Kembla Steelworks as a feedstock within the NGER reporting data would add 1.6 Mt CO_2-e, further increasing sectoral reporting and coverage.

Broader emissions pricing coverage would support competitive neutrality between facilities above and below the threshold. The EPA's load-based licensing arrangements could be applied to drive abatement for small- and medium-sized manufacturers should the Commonwealth choose not to expand the Safeguard Mechanism.

Box 5: Case study: Orica's Kooragang Island facility

Orica's Kooragang Island facility is the largest chemical emitter in New South Wales and was responsible for around one Mt CO_2-e in 2022–23. It is covered by the Commonwealth Safeguard Mechanism.

Recent changes to the Safeguard Mechanism are credited with providing Orica policy certainty to commit to Kooragang Island's decarbonisation. The NSW Government's NZIIIP program provided a grant of $13.1 million, while the Commonwealth Government's Clean Energy Finance Corporation (CEFC) provided Orica $25 million in financing. The Clean Energy Regulator also approved the project to generate ACCUs.

To address the site's residual emissions, Orica aims to replace natural gas feedstock with renewable hydrogen for its ammonia production. It will locate its Hunter Valley hydrogen operations on Kooragang Island, alongside its existing facilities. The hydrogen facility is receiving $70 million from the Commonwealth's Regional Hydrogen Hubs Program and $45 million from the NSW Hydrogen Hubs Initiative. It is expected to be able to produce up to 5,500 tonnes of green hydrogen per year.

[6] Based on 2021-22 National Greenhouse and Energy Reporting.

3.3 Other issues in the manufacturing transition

Over the coming decades, New South Wales will still require most products of today's manufacturing sector. Cement, steel, and aluminium, for instance, will remain in high demand through the energy transition. We are also likely to see shifts in the jurisdictions across the world that hold competitive advantages in making these products. These shifts could prove significant.

Decarbonising manufacturing offers New South Wales significant opportunities. Transitioning manufacturing to use renewable energy can boost productivity. Electrification provides both higher energy efficiency and lower costs. It may also offer greater cost certainty than fossil fuels, as the gas price shocks of 2021 demonstrated. Moreover, demand response in the National Electricity Market means manufacturing production can respond flexibly to electricity prices. This can both reduce input costs and improve grid stability.

Box 6: Australia faces risks from carbon border adjustment mechanisms

Carbon pricing is implemented in 53 countries (World Bank, 2024). Non-pricing regulations such as vehicle and building standards are also common. These policies can shift production away from countries with more ambitious climate policies to those with weaker policies. This is one form of 'carbon leakage'.

A carbon border adjustment mechanism (CBAM) addresses carbon pricing differences by ensuring importers face the same carbon price as domestic producers. The European Union (EU) is developing a CBAM and plans to launch it in 2026. It will require importers to purchase certificates equivalent to the carbon price of the EU emissions trading scheme if the imported good:

- *either* does not face a domestic carbon price
- *or* faces a lower domestic carbon price.

The scheme applies to five emissions-intensive sectors considered at high risk of carbon leakage: cement, iron and steel, aluminium, fertilisers, and electricity. It is not yet clear how the CBAM will treat 'shadow' carbon prices such as those set through the Australian Government's Safeguard Mechanism.

The impact of the CBAM on our exports should be limited, as the EU is not a major export market for New South Wales. However, other jurisdictions are considering options to address carbon leakage, including Canada, China, Japan, and the United Kingdom. The Australian Government is reviewing carbon leakage issues, with a second stage consultation paper released in November 2024 (DCCEEW (Commonwealth), 2024).

Manufacturing decarbonisation offers an opportunity to expand the state's export market for energy-intensive products. Global decarbonisation will create demand for new products such as batteries, EVs, green hydrogen, and wind turbines. Two decarbonising export scenarios could unfold:

- **Slow decarbonisation** could occur because of lagging government and industry action. With exports facing potential CBAMs, international competitiveness could drop, risking a fall in global market share. This also increases the risk of stranded fossil fuel assets and write-downs by NSW businesses later.
- **Rapid decarbonisation** could occur if governments take strong action to align public and private sector abatement activities to legislated emissions targets. It has been estimated Australia could grow its revenue from green exports to $333 billion by 2050 – almost triple the value of current fossil fuel exports (Beyond Zero Emissions, 2021).

The global race to decarbonise manufacturing has begun. Other countries are moving quickly to attract investment and secure market share. New South Wales potentially holds a competitive advantage: it has abundant renewable resources, large deposits of critical minerals, and a highly skilled workforce. These resources could support new green export markets, with products not facing the risk of CBAMs. Overseas policies implemented in large economies (Box 7) could both complement and compete with an accelerated domestic transition to net zero.

Box 7: Overseas green industry support initiatives

In 2022, the United States committed over A$550 billion to stimulate investment in renewable energy infrastructure and clean energy manufacturing. It has already attracted more than A$220 billion in private investment in clean energy projects, including new solar, battery, and EV manufacturing.

The *Inflation Reduction Act 2022* (US) (IRA) is expected to increase demand for critical minerals used in batteries and EVs, offering an opportunity for New South Wales. However, the IRA will also attract global investment and skilled workers to the US. Competition for labour and capital has further intensified with the announcements by the EU, Japan, and Korea of similar industry support packages.

The change in US administration in January 2025 leaves the future of the IRA unclear.

4 Mining and extraction

4.1 Overview

Mining and extraction emissions in New South Wales arise from mining coal and minerals prescribed by the *Mining Act 1992* (NSW) (and other associated acts, regulations, and relevant government strategies). Examples include copper, gold, silver, and quarry products. Historically, emissions have arisen from extracting gas and oil. Currently, however, there is only one gas project in planning (Santos' Narrabri project) and no oil projects.

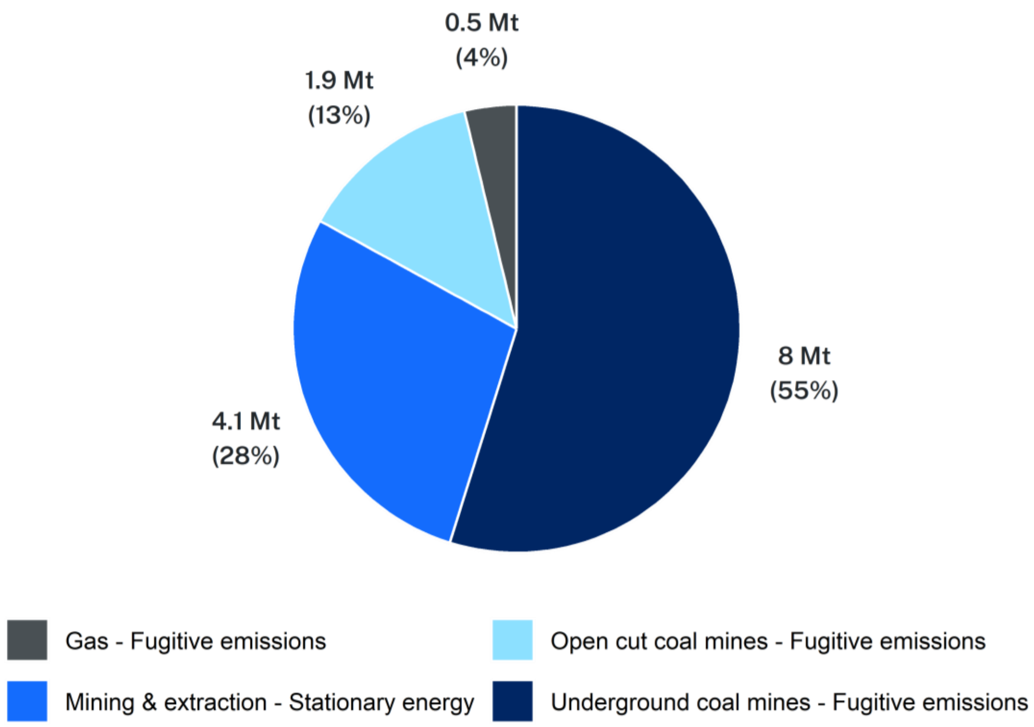
Mining and extraction created 14.5 Mt of CO_2-e in 2021-22, or around 13 per cent of state emissions. These emissions are of two types:

- **Fugitive emissions** occur through the extraction, processing, storage, and delivery of minerals and liquid. They account for about 72 per cent of mining and extraction emissions, or 10.6 Mt CO_2-e per year.
- **Stationary energy emissions** arise from fuel combustion to generate on-site energy to support mining and extraction activities. These reached 4.1 Mt CO_2-e in 2021-22, or about 28 per cent of the sector's total emissions. These emissions are driven by the use of diesel fuel to power mobile plant and equipment (haul trucks, dozers, and loaders) and transmission and distribution of natural gas.

Emissions data by categories and activities are shown in Figure 6.

Figure 6: NSW mining emissions are dominated by coal

Mining and extraction emissions by source, 2021-22



Source: DCCEEW (Commonwealth), 2024.

Coal

Coal mining dominates mining and extraction emissions. Since 1 July 2024, there have been 36 coal mines actively producing coal in New South Wales. Of these, 19 are open-cut mines, 16 are underground mines, and one mine (Moolarben) is both open-cut and underground. Coal mining emissions were 13.3 Mt CO_2-e in 2021-22, with 10.0 Mt CO_2-e being fugitive emissions.

Fugitive emissions from coal mines include:

- venting or other releasing of greenhouse gases before coal is mined
- release of methane and carbon dioxide during coal mining
- carbon dioxide release from flaring of coal mine waste gas
- post-mining activities (decommissioning and rehabilitation) and emissions from abandoned mines.

Most coal output in New South Wales is produced by open-cut mines, but underground coal mines are responsible for most coal emissions. Fugitive emissions from underground mines are projected to be 11.3 Mt CO_2-e in 2024-25, while open-cut mines are expected to emit 2.1 Mt CO_2-e.

Measurement of fugitive emissions from mine sites, particularly open-cut mines, is difficult. Moreover, coal mines, especially underground mines, can have a long tail of fugitive emissions that continue to leak out. Emissions from decommissioned sites can be reduced by flooding the mine and trapping gases in the fractured gas-bearing strata, open vents, seals, and water (UNECE, 2019).

DCCEEW's emissions projections are, in turn, based on projections for coal mining activity based on three categories of mine: 'approved', 'under assessment', and 'closed and decommissioned'. Coal production is projected to be 50 million tonnes in 2050 for the 'current policy – abatement as tracking' scenario based on assumptions about further development consents. (All existing consents expire before 2050.)

All projected fugitive emissions come from open-cut mines, as current policy settings are assumed to ensure 100 per cent abatement in underground mines by mid-century. They also assume there will be uptake of abatement technology in open-cut mines. The net estimate is a projected 1.6 Mt CO_2-e of fugitive emissions in 2050.

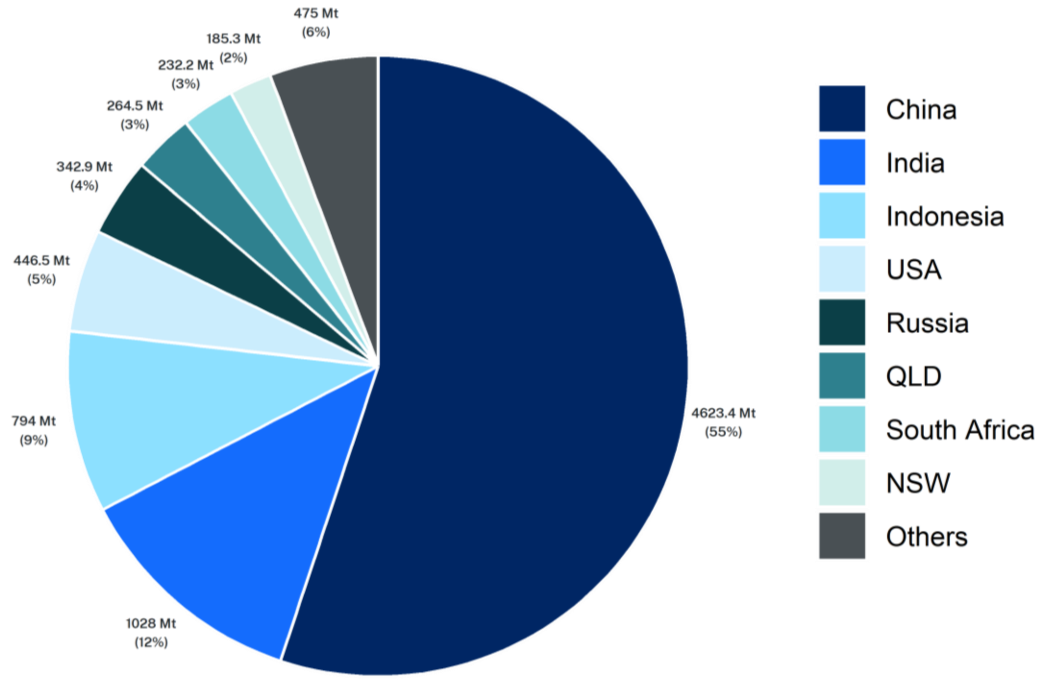
Domestic coal demand for use in electricity generation is projected to be close to zero well before 2050. The AEMO (2024b) 'step change' scenario projects New South Wales to have exited coal-fired electricity generation by 2037. (For comparison, the 'progressive change' scenario projects exit by 2040 and the 'green energy exports' scenario projects exit by 2032).[7] Other states are expected to decommission their coal generators by 2035. This would leave demand for NSW thermal coal confined to domestic stationary energy generation and export.

[7] Expert feedback on the 2024 ISP identified 'step change' as the most likely scenario (43 per cent), narrowly ahead of 'progressive change', a less optimistic scenario for emissions reduction (42 per cent). 'Green energy exports' — the most optimistic scenario for decarbonisation — was voted a distant third in likelihood (15 per cent) (AEMO, 2023).

Around 87 per cent of coal mined in New South Wales is exported. The state is the world's fourth-largest coal exporter after Indonesia, Queensland, and Russia; the source of 11 per cent of global coal exports in 2022 (see Figure 7). Overall, NSW produced around two per cent of the world's coal supply in 2023-24 based on IEA data. Of Australia's customers, China and India were both larger producers but consumed their output domestically.

Figure 7: NSW is the world's eighth-largest coal producer

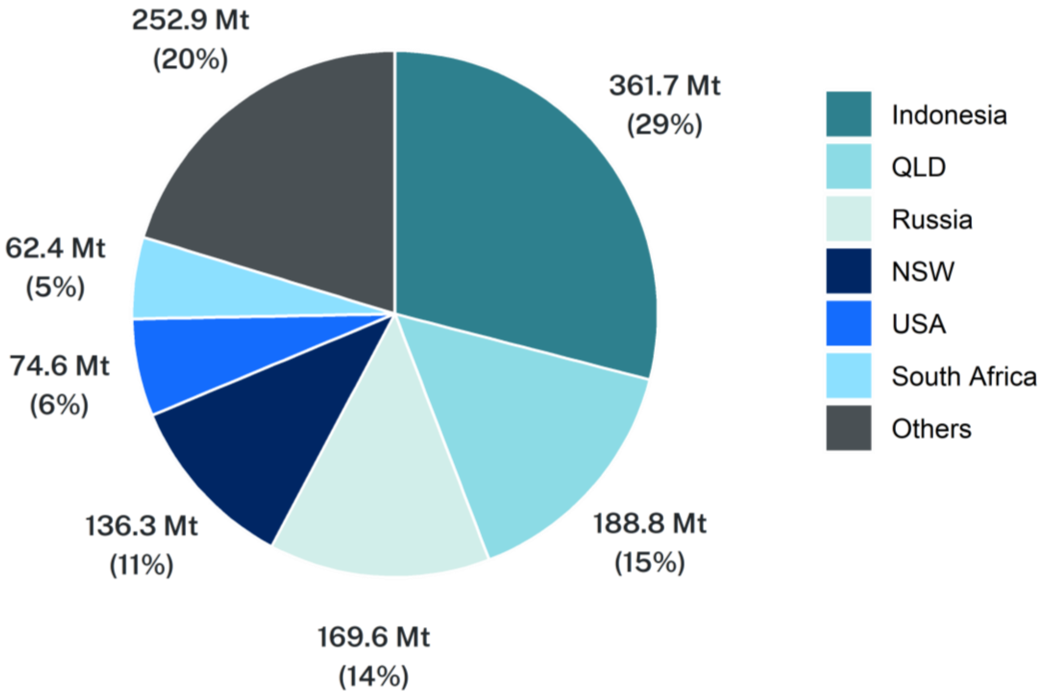
Global coal production by jurisdiction, 2023-24



Note: Excludes lignite.
Source: Commonwealth Office of the Chief Scientist, 2024; IEA 2024.

Figure 8: NSW is the world's fourth-largest coal exporter

Global coal exports by jurisdiction, 2022

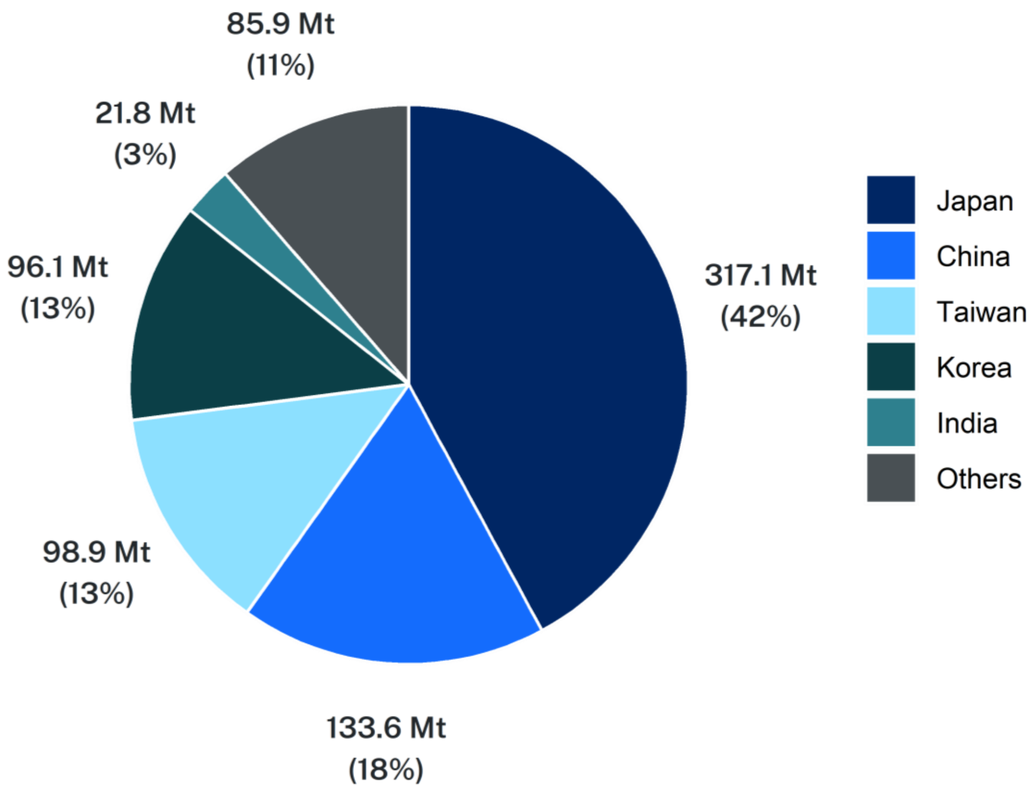


Note: Includes metallurgical and thermal coal.
Source: Department of Infrastructure, Transport, Regional Development, Communications, and the Arts Freight Data Hub 2024, IEA 2024.

NSW coal miners benefit greatly from proximity to Asian markets. The world's largest importers of coal are all in Asia: China, India, Japan, Korea, and Taiwan. These five markets make up around 63 per cent of global coal imports and are the recipient of 82 per cent of Australian coal exports (Figure 9).

Figure 9: Most NSW coal exports are destined for Asia

NSW coal exports by destination, 2016-2020



Note: Analysis was limited to the five years from 2016-20 to avoid the impact of China's de facto ban on Australian coal exports in December 2020. Australian coal exports to China restarted in 2023. (Includes metallurgical and thermal coal.)
Source: Department of Infrastructure, Transport, Regional Development, Communications, and the Arts Freight Data Hub 2024, IEA 2024.

These large Asian markets all have large electricity demand, and in the case of Japan, Korea, and Taiwan, lack significant domestic fossil fuel reserves. India and China both produce more coal than Australia but rely on imports to cover gaps in domestic demand and for higher energy coking coal for steelmaking.

Global coal demand reached an all-time high in 2023 as China rebounded from COVID-19 restrictions (IEA, 2024a). Despite this, Australian coal export volumes in 2023-24 remained below 2010s levels (Department of Science, Industry, and Resources, 2024).

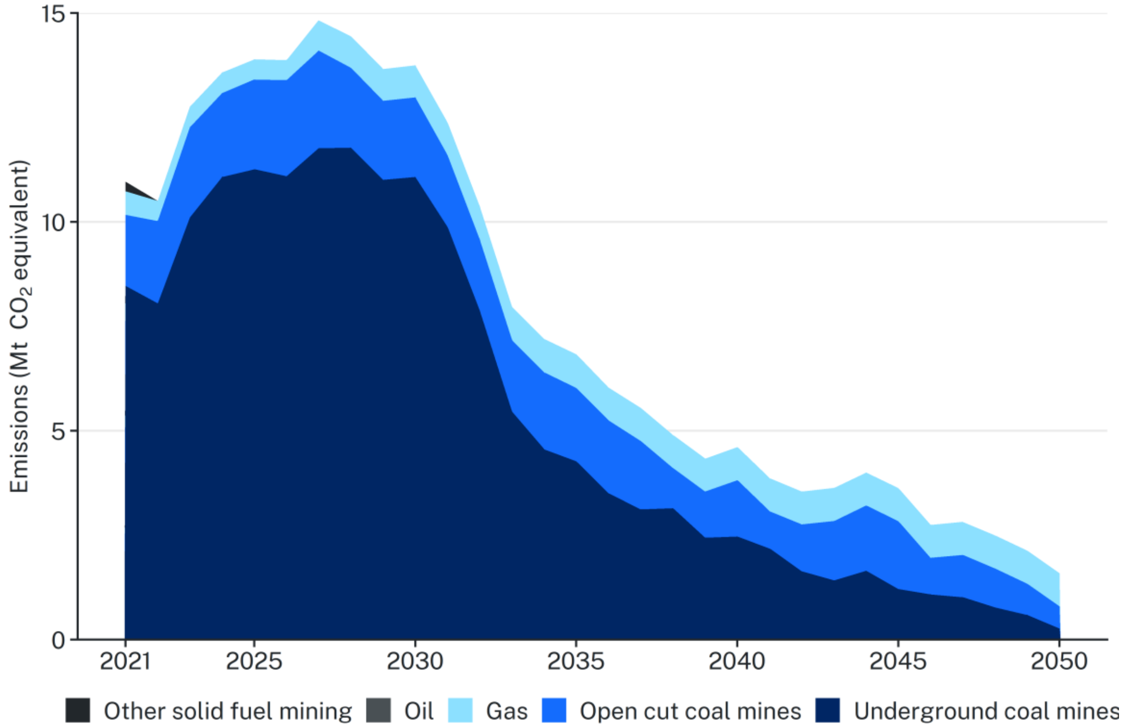
Overall coal demand has recently flatlined or slightly fallen in many of Australia's major export markets (see Box 8).

Total global energy demand, and the precise mix of coal versus renewables in emerging and developing economies, is highly uncertain. Among other factors, the variability in climate change mitigation scenarios internationally makes forecasting and projecting export demand difficult.

The IEA is the OECD's international energy forum comprised of 29 industrialised countries including Australia. The IEA is projecting international coal demand to peak this decade (IEA, 2023). Rapid falls are not expected in the next few years, however. Falling thermal coal demand in advanced economies is expected to be offset by increasing demand for metallurgical and thermal coal from developing economies like India and Vietnam (IEA, 2024a).

Figure 10: Fugitive emissions are set to fall as underground coal mines close

Projected fugitive emissions data for New South Wales by subsector



Note: 'Current policy – abatement as tracking' scenario[8].
Source: (DCCEEW, 2024).

Demand for metallurgical coking coal is uncertain. Coking coal is currently used as a key feedstock for metal production. Currently, it accounts for around 20 per cent of New South Wales's raw coal output (Coal Services, 2024). Coking coal supplies the Port Kembla Steelworks and other steel manufacturers around the state.

Steel is critical for the net zero transition, as the production of solar panels, wind turbines, batteries, and electric vehicles requires this input in large amounts. Global steel demand is forecast to rise 30 per cent by 2050 (World Economic Forum, 2022). It is unclear if or when zero emissions alternatives will outcompete coal in the coking process.

Box 8: Demand trends in NSW coal export markets

While future coal demand is uncertain, most projections trend toward significantly reduced demand by 2050 (IEA, 2022; EIA, 2023; Wood Mackenzie, 2024; IEA, 2024b).

NSW coal exports had remained steady at around 135 million tonnes per year for most of the past decade despite growing international demand. There are noticeable

[8] The 'current policy - abatement as tracking' projection accounts for uncertainties around the abatement speed and capacity of current policies.

downward trends in coal use by some of our main trading partners. How these trends will impact long run demand for NSW coal is not clear.

- Japanese electricity demand has fallen by around 10 per cent since 2010, with solar and nuclear progressively replacing coal in the generation mix.
- In Korea, the share of coal-fired electricity has fallen by around 20 per cent since 2018, with the shares for gas-fired and nuclear-generated electricity rising.
- Taiwanese demand for thermal coal has flatlined since the mid-2000s as it shifts to natural gas to support rising electricity demand.
- The IEA projects China's overall demand for coal out to 2027 will be flat. Chinese coal imports were lower in 2023 than they were in 2013. Chinese coal demand is likely being subdued by the falling cost of renewables as an alternative way to increase electricity supply.
- India typically imports higher-grade coking coal while using domestically produced thermal coal for electricity generation. Overall, Indian coal imports have flatlined since 2014.

Other mining

In 2022-23, NSW mining other than coal is estimated to have emitted approximately 480,000 tonnes of CO_2-e, the majority arising from stationary energy. Most of these emissions came from gold mines, including one Safeguard-listed facility (the Cowal gold mine). Copper mining and quarries are also the source of emissions.

Gas

New South Wales has traditionally relied upon locally extracted gas for electricity generation, manufacturing processes, and use in residential, commercial, and industrial buildings. Currently, no gas extraction facilities operate in New South Wales and natural gas fugitive emissions were just 0.5 Mt CO_2-e in 2022-23. Over half of these emissions were from the Jemena Gas Network (formerly AGL Gas Networks). The rest was from exploration, venting, and flaring activities, which leak methane and carbon dioxide.

Around 40 per cent of natural gas in New South Wales is used in industry, compared to 35 per cent in buildings (e.g. for heating and cooking) and 19 per cent for power generation (Department of Industry, Science and Resources, 2024). Natural gas is currently important in several difficult-to-abate industries where it provides both stationary energy for heating (e.g. cement manufacturing) and a chemical input (e.g. plastics and fertilisers). As discussed in Chapter 3, technologies are available to mitigate these emissions but may take time to develop and implement.

New South Wales has significant recoverable gas reserves, mostly in coal seams. Extracting gas from these seams generally comes at a high cost. It also creates local environmental impacts and generates community concerns. These concerns were reflected in a relatively restrictive Strategic Release Framework, published in December 2015, which placed strict conditions on granting title for exploration of unconventional and coal seam gas. To date, only the Narrabri Gas Project has been approved under the Framework. This project is still in development. Moreover, the 2021 Future of Gas statement significantly reduced the amount of land available for gas exploration.[9] As a result of falling production on the east coast, wholesale gas prices have become more strongly linked to international prices.

Much of the gas consumed in New South Wales is transported via pipelines from Queensland and South Australia. Squadron Energy's Port Kembla Energy Terminal is due for completion in 2025. Imported LNG will be converted to natural gas at this facility before being pumped into the east coast gas system.

AEMO's 2024 *Gas Statement of Opportunities* forecast a 2027 supply gap in its 'green energy exports' scenario for New South Wales, Victoria, South Australia, and Tasmania (AEMO, 2024c). The ACCC has also indicated that short-term supply pressures created by the 2022 global energy crisis are easing, but an east coast gas shortfall could still occur in 2027 (ACCC, 2024). The Institute of Energy Economics and Financial Analysis found energy efficiency, electrification, and moderation in industrial demand could close the forecast supply gap across the southern states (IEEFA, 2024).

Moderating gas demand would better complement the state's legislated emissions reduction commitments. Moreover, in the absence of comprehensive carbon pricing, gas policy in New South Wales needs to carefully prioritise the strategic use of this resource in the net zero transition. Stocks might need to be conserved for peak electricity generation and hard-to-abate industrial activities.

The forecast gas shortage is an opportunity for the NSW Government to consider the NSW Productivity Commission's 2021 recommendation for a demand management strategy for gas.

A demand management strategy could simultaneously encourage decarbonisation, reduce costs, and conserve gas stocks for difficult-to-abate activities. Any gas strategy should also be built on three key pillars:

1. Substituting for gas use where there is a clearly cost-effective alternative.
2. If substitution is not possible, then the fuel efficiency of equipment and appliances should be the focus.
3. For activities that cannot be electrified, low-emissions alternatives to natural gas should be used instead, like biogas and renewable hydrogen.

[9] The Strategic Release Framework is less strict than in other jurisdictions. Victoria has had a moratorium on unconventional onshore gas exploration — including coal seam gas — since 2017. Tasmania has a moratorium on hydraulic fracturing ('fracking') — a coal seam gas extraction method — until 2025.

4.2 Decarbonising mining and extraction

Meeting emissions reduction commitments in mining and extraction will involve a combination of:

- reducing fugitive emissions through pre-drainage and ventilation air methane abatement
- use of ammonium nitrate derived from green ammonia in explosive activities
- substituting zero-emissions energy for fossil fuel combustion
- purchasing Australian Carbon Credit Units (ACCUs) or other offsets under a similar scheme.

These abatement opportunities could be driven by a more ambitious Safeguard Mechanism, possibly with load-based licensing for smaller mines. Governments could also consider taking policy decisions to disallow new mining and extraction licences and/or extensions to existing licences beyond specific dates. The costs and benefits of different combinations of options would need to be weighed.

Technologies for reducing emissions

Fugitive emissions

Reducing fugitive emissions from coal mining poses a challenge. Abatement technologies are at varying points of maturity, both technologically and commercially. In general, the abatement potential is significantly higher for large, porous underground coal mines and lower for open-cut mines where emissions are more diffuse. Coal seams naturally contain methane, which is released during and after mining operations. Methane emissions are generally higher in underground coal mines because they target deeper coal seams. But the funnel-like nature of underground mines makes their fugitive emissions easier to capture than those from open-cut mines.

The CSIRO has been developing technologies that can reduce fugitive emissions from coal mines by more effectively capturing and destroying methane (CSIRO, 2021).

Captured methane can be concentrated and:

- *either* used to generate electricity
- *or* abated by being 'flared' and turned into carbon dioxide, which is about 28 times less potent of a greenhouse gas, with the CO_2 subsequently offset with ACCUs.

In 2019 the CSIRO and South32 Illawarra conducted a pilot of the CSIRO's safer, catalytic mine ventilation air methane abatement technology. A preliminary lifecycle assessment of the technology estimated a net reduction in emissions from the studied mine of around two thirds (CSIRO, 2024).

These technologies have the potential to reduce the emissions intensity of mining actives in New South Wales. They need, however, to be further tested, commercialised, and deployed to help drive emissions down.

IEA estimates only 20 per cent of open-cut mine fugitive emissions are abatable. This is because there are limited options to capture emissions for storage and flaring (IEA, 2023).

Stationary emissions

Technologies to abate stationary emissions are more viable. Plant, equipment, and vehicles powered by diesel can be replaced with models powered by either zero emissions electricity, or renewable fuels like biogas, green hydrogen, and green ammonia.

Long asset lives, however, mean that ongoing investment in fossil fuel-based technologies risks locking in significant future emissions. There are also physical limitations to the level of electrification achievable in mining operations distant from network infrastructure and the built environment. But options exist for alternative investments in renewable fuels and offsets that can contribute to reducing emissions. The alternative is for costly asset replacements to be required later. This highlights the need for the sector to be provided with clear policy signals as soon as possible.

Carbon pricing in the mining and extraction sector

New South Wales has 28 mining and extraction facilities covered by the Commonwealth Safeguard Mechanism. These facilities emitted 12.5 Mt CO_2-e in 2021-22 and accounted for around 89 per cent of total mining and extraction emissions (CER, 2024a). Assuming the Safeguard Mechanism continues to drive abatement at large facilities, these have a pathway to net zero.

Implementing the Commonwealth Productivity Commission's recommended lower Safeguard Mechanism threshold of 25,000 tonnes of CO_2-e would cover an additional 11 facilities accounting for over 300,000 tonnes of extra emissions in 2021-22. This would increase coverage of the sector to 91 per cent and improve competitive neutrality between facilities above and below the threshold. But if the Commonwealth is unwilling to adopt this recommendation, the EPA's load-based licensing arrangements could be applied to drive abatement for small- and medium-sized mines (see Chapter 1).

Licensing and development consents for mining and extraction

The framework outlined in our first paper emphasised the cost-effectiveness of emissions pricing. The Commonwealth's Safeguard Mechanism provides a realistic pathway to reduce emissions over time, provided its abatement trajectories are broadly consistent with the NSW legislated targets. Large new mines would similarly be included in the Safeguard Mechanism if, and when, they come online. But strategic decisions around the future of coal could also be a cost-effective option for reducing mining emissions. As discussed in our first paper, such decisions should be informed by best practice cost-benefit analysis. These decisions should assess the relative cost-effectiveness of alternative abatement opportunities across the economy.

Coal mining in New South Wales requires a development consent from either DPHI or the Independent Planning Commission and a mining lease from NSW Resources. These processes are all subject to policy decisions by ministers.

To be commercially feasible, a coal project needs an estimate of the expected cost of meeting Safeguard Mechanism (and other emissions pricing) obligations. Abatement costs under the Mechanism are indirectly determined by Australia's Nationally Determined Contribution (NDC) under the Paris Agreement. But the NDC was yet to be set even for 2035 at the time of writing. The NDC, combined with market conditions, will determine actual emissions prices — including for SMCs and ACCUs — over the life of a coal project. Uncertainty around the NDC makes compliance costs highly uncertain for coal projects beyond the medium term. Under some scenarios, abatement costs could be too high for some projects to proceed. Other projects could be rendered unviable faster than expected, leaving capital stranded and employees without sufficient time to adjust to new careers. The viability of projects also depends on the strength and certainty of the outlook for international coal demand (see Box 8).

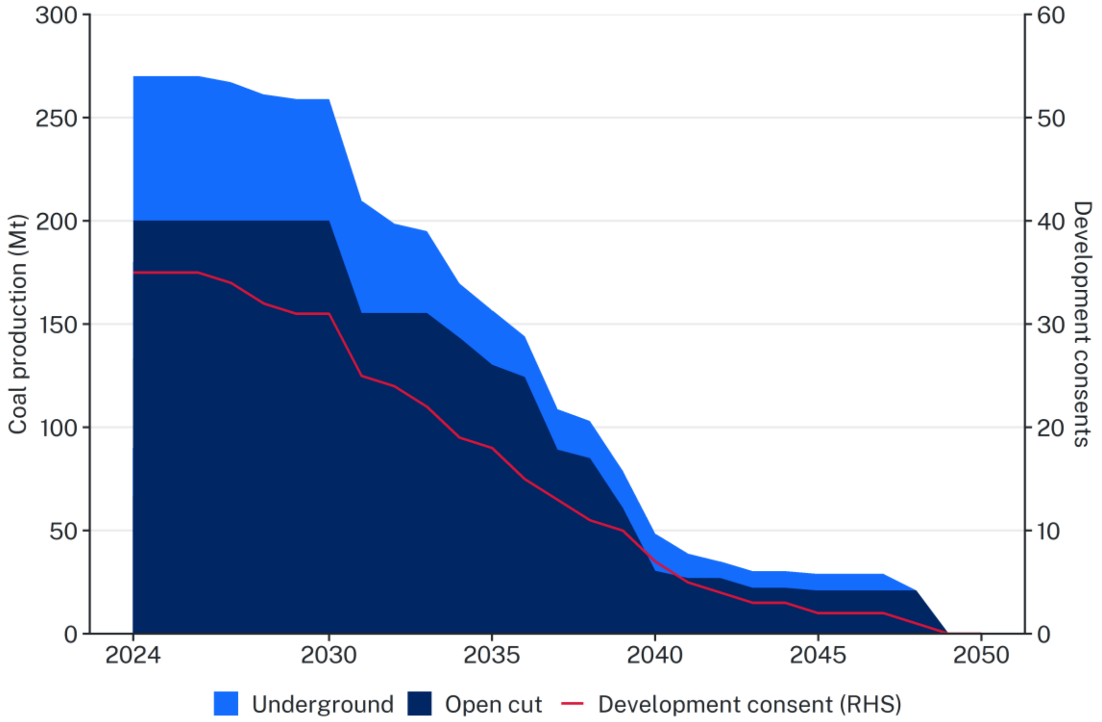
Strategic decisions by government that provide a more certain picture on the future of coal could, under these scenarios, supersede emissions pricing as the cost-effective pathway for the mining sector. In these circumstances, the state's resources would be reallocated over time toward less emissions-intensive activities that carry less risk and uncertainty about emissions reduction policy. One approach could be to:

- identify domestic needs, and then lock in operations for:
    - thermal coal for domestic electricity generation until coal power stations close
    - metallurgical coal for domestic manufacturing activities and export.
- give a clear deadline for decommissioning thermal coal mining for export.

Another option is to consider preventing new mine approvals or ensuring stringent abatement requirements as set out in the draft *Climate Change Assessment Requirements and Guide* (EPA, 2024). If such a decision were taken, development consents would provide a predictable pathway for reducing fugitive emissions from coal operations (Figure 10). By 2040, output will have fallen by more than 85 per cent. By 2048, all current licences are set to have expired.

Figure 11: Coal output will significantly fall as development consents expire

Development consent expiry dates and coal output for NSW mines



Note: The active development consent count as of 2024 includes only those mines that are in active production and not mines placed in 'care and maintenance' or 'closure' phases.
Source: (NSW, 2024; Global Energy Monitor, 2024; CER, 2024b).

NSW Government emissions projections currently include some 'likely' coal mine extensions based on published proposals. Not approving these extensions could reduce mining emissions in the 2030s and 2040s markedly.

Were this path taken, to minimise transition costs, governments would need to signal a coal strategy clearly and with enough time for the mining industry to respond. The NSW Independent Planning Commission has approved eight major new coal projects and expansions in the past five years. There have been limited applications for new mine exploration in recent years. Those that have been received are within the current policy of being in a restricted area adjacent to existing operations. New applications could be received at any time.

4.3 Other issues in the mining transition

Downstream emissions

As discussed, coal mines themselves emit significant greenhouse gases. But emissions associated with coal are overwhelmingly scope 3 emissions, which happen when coal is burned. As approximately 85 per cent of coal mined in New South Wales is exported, these emissions are not captured within the state's greenhouse gas accounting under UN practices. This is notwithstanding significant tax revenue (including NSW coal royalties) generated by coal mining activities.

As outlined in Box 8, the future of New South Wales' coal export industry is uncertain because the trajectory of international demand is difficult to predict. Further, the state's fossil fuel exports may come under increasing international scrutiny if Australia continues without a clear plan for exiting coal. This exposes the coal and gas industries to risks, including carbon border adjustments in destination countries or the withdrawal of financing. These risks increase the probability that mines could be forced to cease operations abruptly. This could strand assets, cut government revenue, and leave employees without a smooth transition to new careers.

Box 9: NSW coal quality, carbon leakage, and global emissions

The Climate Change Act's legislated targets are for net greenhouse gas emissions in New South Wales. The *Achieving net zero* series focuses on reducing NSW emissions. The Act's overriding purpose, however, is to give effect to commitments to limit global temperature increases (UNFCCC, 2015). It is worth reflecting, then, on potential global impacts of NSW climate change mitigation policies.

One question is whether reductions in NSW coal exports could cause carbon leakage, for example, through importing nations using higher-emissions fuels instead of NSW coal. Coal mined in New South Wales has low ash and high energy density compared to the global average, which is heavily impacted by Indonesia's poor coal quality. But the difference in emissions intensity (unit of CO_2-e released per unit of energy created) between bituminous Australian coal and Indonesian sub-bituminous coal is only around four per cent (US EPA, 2016).

The emissions intensity of coal combustion is also more dependent on the efficiency of the power plant than the quality of the coal used. Newer plants produce around 25 per cent fewer emissions than older ones (Hardisty, Clark, & Hynes, 2012). Coal from New South Wales is also not unique in its relatively high energy density, so importing nations also have potential high-quality alternatives. Coal from Russia and South Africa, for example, has similar energy density to NSW coal, and has the extra benefit of being low in sulphur and ash (S&P Global, 2020).

Another international effect that should be considered is how reductions in NSW coal exports could affect global emissions by influencing international coal prices and demand. New South Wales produces around 11 per cent of global coal exports. This is the fourth-largest share, behind Indonesia, Queensland, and Russia. Limiting future NSW coal exports would be expected to raise the global price relative to otherwise, particularly for thermal coal. Coal importers would respond with a combination of:

- reducing coal-generated energy demand, lowering emissions
- accelerating their switch to low- and zero-emissions energy sources like firmed renewables, replacing coal-fired electricity and lowering emissions
- boosting local production or purchasing coal from alternative suppliers — potentially, but not necessarily, increasing emissions.

All things being equal, reducing NSW coal exports will only result in a net increase in global emissions if the third effect is stronger than the combination of the first two. Evidence is emerging that suggests global coal demand is becoming more responsive to changes in price (Huntington, Barrios, & Arora, 2019), particularly in China (Burke & Liao, 2015).

This is because of an increasing array of alternative energy sources. Markets can switch not only to longstanding alternatives like nuclear and natural gas, but increasingly to renewables and storage, which are becoming cheaper over time.

The Methane Pledge

New South Wales' coal mining makes an outsized contribution to national methane emissions. The IEA's 2023 Methane Tracker reported that Australia's coal mines produced 1.67 Mt of methane in 2023 (IEA, 2024).

The Global Methane Pledge is a voluntary commitment to reduce methane emissions by at least 30 per cent below 2020 levels by 2030. Australia became a signatory to the non-binding pledge in October 2022, committing to take actions to reduce methane emissions in the energy, waste, and agricultural sectors. Given technological viability and lead time, reaching this target would require a significant contribution from reduced fugitive emissions.

The critical minerals and metals opportunity

Critical minerals and metals are needed for the energy transition. Their seams contain little or no methane, so no meaningful fugitive emissions are released during the mining process. Rather, emissions are generated from on-site fuel combustion for mining, processing, and transportation. Net zero will require transitioning these processes to zero-emissions technologies.

The IEA has projected a surge in global demand for lithium, cobalt, nickel, and copper. It estimates a need for a further 50 lithium mines, 60 nickel mines, and 17 cobalt mines by 2030 to meet emissions goals (IEA, 2022). New South Wales could meet some of this demand, having 21 of the 31 nationally identified critical resource commodities and four of the five minerals on the Australian Strategic Materials List (NSW Department of Primary Industries and Regional Development, 2024). The state also ranks second nationally in demonstrated resources endowment for copper, and third for cobalt and nickel (NSW Department of Primary Industries and Regional Development, 2024).

The state has advantages in making the transition from coal to critical minerals mining, including a skilled workforce, regulatory certainty, and a strong mining, equipment, technology, and services sector. However, there will also be challenges. For example, critical minerals are often located in remote locations, away from existing coal mining workers and infrastructure like ports.

The transition will also impact the state's finances. Over the next four years, the NSW Government is set to receive around $13 billion in royalty payments – two to three percent of total state revenue. Almost all royalty payments in New South Wales come from coal. If coal production declines, royalties from increased production of critical minerals like copper and cobalt will only offset a small amount of lost revenue.

5 Waste

5.1 Overview

Waste includes household, business, and public sector biodegradable and non-biodegradable waste, popularly known as rubbish and sewage. Management of this waste creates, ironically, other wastes – including greenhouse gases.

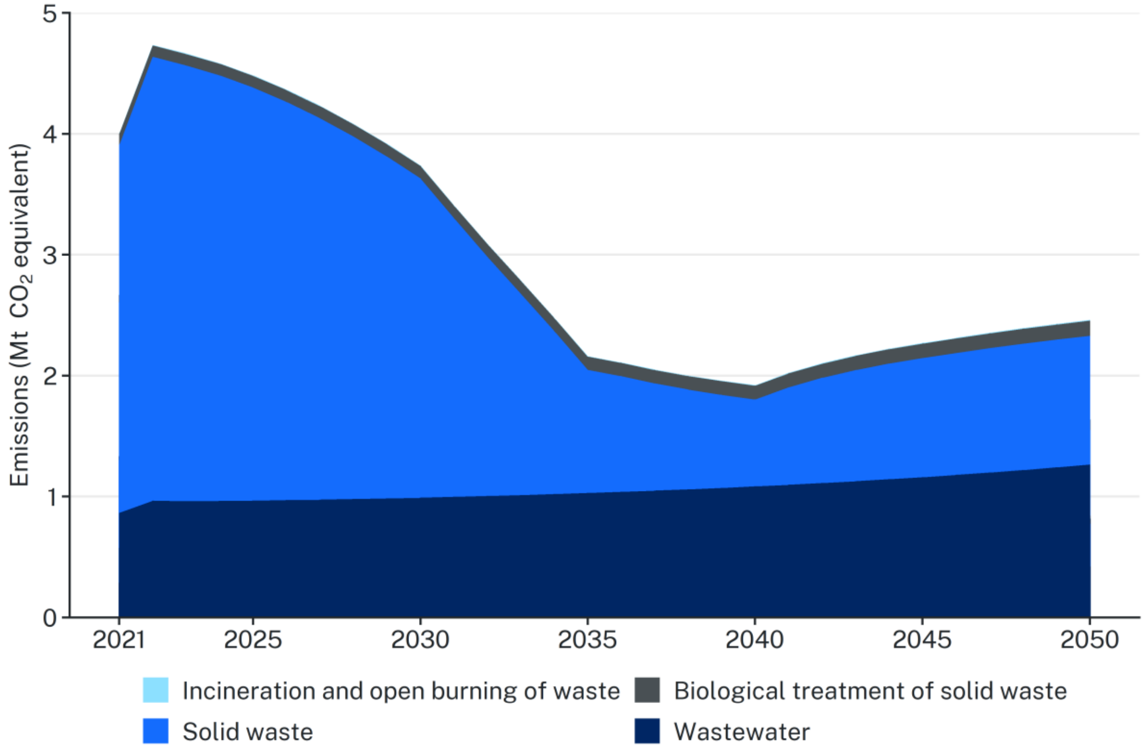
Waste emissions totalled 4.7 Mt CO_2-e in 2022-23, around 3.6 per cent of New South Wales' total emissions. These emissions are made up of three different streams:

- Solid waste emissions come from decomposing organic matter, which is sent to landfill. We estimate these totalled 3.6 Mt CO_2-e in 2022-23, or 77 per cent of all waste emissions.
- Wastewater treatment creates methane, carbon dioxide, and nitrous oxide, for an estimated 1.0 Mt CO_2-e yearly, or 21 per cent of all waste emissions.
- Incineration and biological waste treatment emissions make up an estimated 0.1 Mt CO_2-e, or two per cent of all waste emissions.

Waste management involves both public and private operations. The NSW Government oversees waste management policy, regulation, and some services.

Figure 12: Waste emissions are projected to fall – but then resume rising

Projected emissions from waste in New South Wales, by IPCC subsector 2021-50



Note: 'Current policy – abatement as tracking' scenario.
Source: (DCCEEW, 2024).

Between 1990 and 2015, waste emissions fell by more than 50 per cent, but progress has stalled since. Emissions are expected to fall again as less waste goes to landfills and as gas capture increases. Waste emissions are now projected to fall to 2.2 Mt CO_2-e by 2035, 61 per cent below 2005 levels. After 2040, waste emissions are projected to *rise* because of population growth and the lack of additional abatement technologies to offset increased levels of waste.

There were three waste facilities in New South Wales covered by the Commonwealth Safeguard Mechanism in 2021-22. Two have since been amalgamated and the third dropped out of the Mechanism. In 2021-22 these facilities were responsible for 0.2 Mt of emissions. Lowering the threshold to 10,000 tonnes would cover 22 additional facilities, responsible for around 1.1 Mt CO_2-e.

5.2 Achieving net zero in waste

Technologies to lower waste emissions

Waste sent to landfill is a large source of methane emissions. This methane is generated when bacteria begin to decompose waste. Organic matter, which makes up over half of all household waste (ABS, 2020), is the biggest driver of methane emission from these bacteria. But it has also been shown that plastics left to break down in landfills produce methane as well (Royer, Ferron, Wilson, & Karl, 2018).

Several technologies can reduce waste sector emissions, including:

- Protein farming: this new food waste management option converts food waste to protein for animal feed using insect larvae. Modelling suggests protein farming can have significant greenhouse gas (GHG) benefits if the harvested insect larvae protein is substituted for other protein in animal feed (Blue environment, 2023).
- On-site dehydration: dehydration units can dry food that in some situations may be managed on-site, but more typically needs to be applied to land or taken to an off-site processor.
- Bio-dehydration: uses biological agents to partially decompose and stabilise food.
- Off-site anaerobic digestion: allowing methane-producing anaerobic digestion to occur in a closed environment and capturing that gas for use, a near-net zero option for replacing fossil fuel consumption. Modelling suggests this has the best GHG emissions outcome after protein farming, although its benefits would decline as the grid decarbonises.
- Off-site composting: a common option for source separated food waste, such as the green organic waste bins provided in many local government areas. Emissions from composting organic waste can be as much as 84 per cent lower than allowing the same waste to decompose in landfill (Perez, Vergara, & Silver, 2023).
- On-site aerobic composting and vermicomposting: on-site composting and 'worm farms' can be used where sites have enough space and resources to manage the

food waste they generate. Ensuring adequate oxygen is available during the composting processes is key to minimising the release of methane (Swati & Hait, 2018).

Waste policy should be based on net economic benefit

NSW Government waste policy is set out in the 2021 *Waste and Sustainable Materials Strategy 2041* (DPIE, 2021). The Strategy aims at 'transitioning to a circular economy over the next 20 years', using waste hierarchy principles. Under the hierarchy, waste avoidance is best practice, followed by reduction, reuse, and recycling.

The waste hierarchy, however, is not necessarily consistent with net economic benefit. Prioritising waste avoidance and reduction in all instances could unduly limit production of inputs and outputs integral to our living standards. Moreover, where waste is inert and landfill capacity is abundant, disposal may achieve the highest net benefits of any waste disposal tactic. Nor would it ensure cost-effective waste emissions abatement. Recycling plastics, for example, is generally not commercially viable, and encouraging recycling could generate more emissions than storage in landfill.

Emissions reduction for the waste sector should favour cost-effective solutions. This would naturally follow from expansion of the Commonwealth Safeguard Mechanism. This would expand NSW waste facilities emissions covered by carbon pricing to around 90 per cent, up from around 15 per cent now. Absent Commonwealth action, the same outcome could be achieved through load-based licensing administered by the EPA.

Absent a carbon price, net economic benefit evaluated through cost-benefit analysis with updated carbon values should be the framework for a revised waste strategy, including waste emissions abatement. This approach would generate superior outcomes than the waste hierarchy.

Appendix A: The Safeguard Mechanism in New South Wales

Table 3: NSW facilities covered by the Commonwealth Safeguard Mechanism, 2022-23

Facility name	Baseline number	Type of baseline	Reported covered emissions	Sector	Facility name	Baseline number	Type of baseline	Reported covered emissions	Sector
Port Kembla Steelworks	6,875,761	Production-adjusted	6,138,128	Industrial processes	**Qenos Botany Manufacturing**[10]	551,253	Calculated	348,554	Industrial processes
APN01 Appin Colliery - ICH Facility	3,280,958	Production-adjusted	2,433,025	Mining - coal	**Ravensworth Operations**	345,281	Calculated	327,434	Mining
Tomago Aluminium Smelter	1,230,271	Production-adjusted	1,177,432	Industrial processes	**JGN**	483,824	Production-adjusted	292,825	Gas
Mandalong Mine	1,443,304	Calculated	1,009,855	Mining	**United Coal Mine**	330,425	Calculated	291,241	Mining
Tahmoor Cola Mine	2,008,287	Calculated	992,938	Mining	**Myuna Colliery**	274,670	Production-adjusted	274,640	Mining
CEM NSW Berrima	1,075,006	Production-adjusted	979,872	Industrial processes	**Russell Vale Colliery**	1,115,025	Calculated	272,086	Mining
Kooragang Island	1,140,746	Production-adjusted	948,229	Industrial processes	**Integra Underground Mine**	721,813	Calculated	265,194	Mining
Warkworth Mine	1,018,733	Calculated	842,536	Mining	**Mt Owen Glendell Complex**	286,172	Calculated	263,395	Mining
Mount Pleasant Operations	838,069	Production-adjusted	816,771	Mining	**Maules Creek Open Cut Mine**	367,513	Calculated	258,093	Mining

[10] Note this facility ceased operations in February 2023.

Facility name	Baseline number	Type of baseline	Reported covered emissions	Sector	Facility name	Baseline number	Type of baseline	Reported covered emissions	Sector
Narrabri Underground Mine	1,116,113	Calculated	786,802	Mining	**Moolarben Coal Mine (open-cut & underground)**	361,814	Calculated	217,119	Mining
Metropolitan Colliery	718,746	Production-adjusted	686,890	Mining	**Wambo Coal Mine**	n/a	Multi-year monitoring period	207,015	Mining
Bengalla Operations	700,840	Production-adjusted	573,941	Mining	**Boggabri Coal Minesite**	202,244	Calculated	192,864	Mining
HVY01 Hunter Valley Energy Coal - CCL Facility	n/a	Multi-year monitoring period	528,632	Mining	**Liddell Coal Mine**	176,827	Calculated	166,197	Mining
Bulga Coal Complex	707,250	Calculated	512,403	Mining	**Wilpinjong Coal Mine**	208,562	Calculated	154,987	Mining
Hunter Valley Operations Mine	633,681	Calculated	456,690	Mining	**Solid Waste Services - Lucas Heights**	315,324	Landfill	129,354	Waste
DEN01 Dendrobium Mine	386,274	Calculated	417,502	Mining	**Mangoola**	122,507	Calculated	117,312	Mining
Ashton Coal Mine (underground)	871,793	Calculated	381,866	Mining	**Cowal Operations**	n/a	Multi-year monitoring period	104,155	Mining
Nowra Plant	461,274	Production-adjusted	363,674	Industrial processes					

Source: (CER, 2024a).

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