NSW Treasury

26 June 2025

Re: Net Zero Commission Consultation Paper

To the New South Wales Net Zero Commission,

I welcome the opportunity to make a submission to the *NSW Net Zero Commission 2025 Consultation* on behalf of the NSW Productivity and Equality Commission ('the Commission'). The NSW Productivity and Equality Commission's purpose is to provide evidence on opportunities to improve productivity and consider equity and how costs and benefits are distributed across the community over time.

New South Wales has legislated ambitious greenhouse gas reduction targets, aiming to reach net zero emissions by 2050, with interim targets for 2030 and 2035. However, based on current policy settings, the state is projected to fall short of targets.

The Commission's 2024 Net Zero report, *Ensuring a cost-effective transition* (Attachment A) examines the State's current course to net zero. It outlines the necessary course corrections for decarbonising the economy and emphasises that, in the absence of an economy-wide carbon price, the transition to net zero must follow clear policy principles including cost-effectiveness, investor certainty, technology neutrality, and coordination across jurisdictions. It also highlights how best-practice policy evaluation can accelerate emissions reductions.

While the electricity sector is progressing toward net zero, emissions span all sectors of the economy. In March 2025, the Commission released its second Net Zero report, *Decarbonising buildings, industry and waste* (Attachment B), focusing on residential, commercial, and industrial buildings, as well as construction, manufacturing, mining, and waste. The report found that although many technological solutions exist, they are not being adopted quickly enough to meet the 2030, 2035, and 2050 targets.

I believe that if action is taken sooner rather than later, NSW can seize the opportunities presented by the net zero transition and deliver better economic, social, and environmental outcomes for the people of NSW.

I note that the Commission's Net Zero papers do not represent NSW Government policy.

Sincerely,

Peter Achterstraat AM
NSW Productivity Commissioner

NSW Productivity and Equality Commission

Ensuring a cost-effective transition

Achieving net zero

Paper 1

November 2024

Acknowledgment 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.

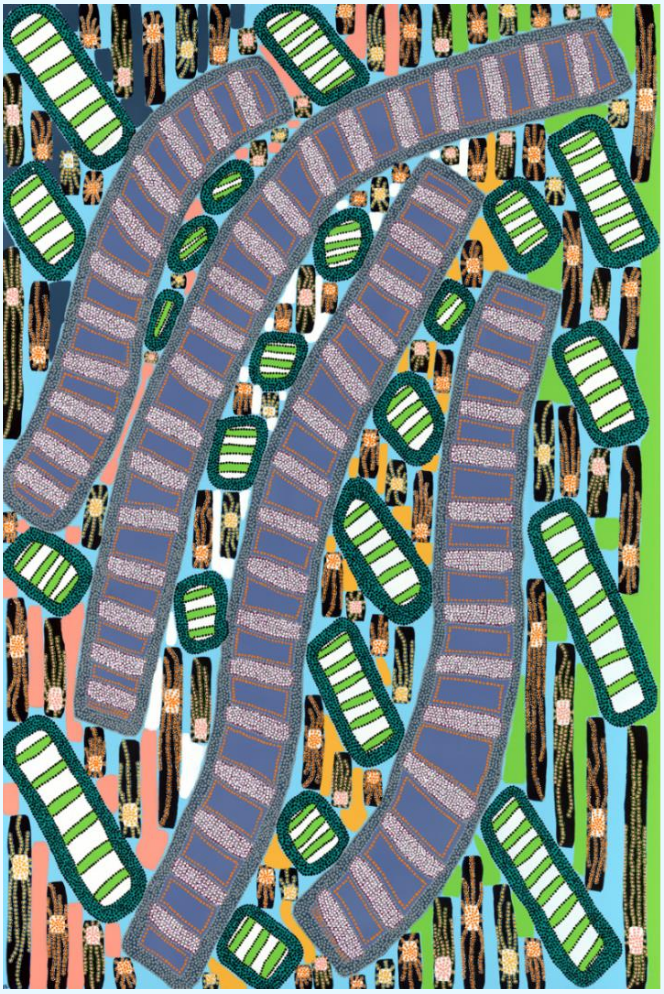
We pay respect to Elders past and present and commit to respecting the lands we walk on, and the communities we walk with.

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.

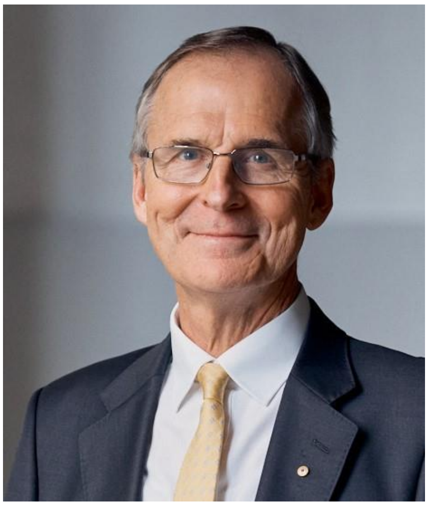
We acknowledge the ongoing stewardship of Aboriginal and Torres Strait Islander peoples, and the important contribution they make to our communities and economies.

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



Commissioner's foreword



New South Wales has legislated ambitious greenhouse gas reduction targets, aiming to reach net zero emissions by 2050, with interim targets for 2030 and 2035.

But we have a problem. Based on current policy settings, the state is projected to fall short of all its targets – 2030, 2035, *and* 2050. Missing our early targets will leave us squeezing bigger, more costly change into a shorter time if we are to reach net zero by mid-century.

The clock is ticking. We need to focus on the policies and solutions that will drive this change. This will ensure that we can reach our targets while keeping productivity and living standards high.

This is the first paper in the NSW Productivity and Equality Commission's *Achieving net zero* series. It clearly sets out the course corrections we need to progressively decarbonise our economy. This paper examines the current state of the transition in New South Wales. The series will also explore how we can achieve net zero in a cost-effective way, in electricity generation, in freight and passenger vehicles, in industrial plants, and in buildings. Above all, it emphasises the need for governments, businesses, and households to make the right consumption and investment decisions.

While a comprehensive emissions price is the gold standard for coordinating economic activity to reduce emissions, no such comprehensive price system currently operates in Australia. This places us squarely in the world of second-best. It will require governments to take a more active role in guiding the transition. This paper explores how existing emissions pricing can be expanded and, alternatively, how best-practice policy evaluation can drive emissions reduction.

I believe that New South Wales can seize the opportunities presented by the net zero transition and emerge by 2050 as an even better place to live, work, and invest.

Peter Achterstraat AM

NSW Productivity and Equality Commissioner

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, Mr Peter Achterstraat AM.

Productivity growth is essential to ensure sustained improvement in living standards for the people of New South Wales. It requires the best possible utilisation of our knowledge, skills, and experience, technological innovations, and capital and environmental assets. The Commission is tasked with identifying opportunities to boost productivity in both the private and public sectors.

The Commission's priorities include:

- efficient and competitive markets
- fit-for-purpose regulation
- innovation
- climate resilience
- sustainable economic development.

In 2024, Mr Achterstraat was reappointed for a further two years in the expanded role of Productivity and Equality Commissioner.

The Commission provides objective, evidence-based advice to the NSW Government. In performing its functions, the Commission considers equity – how the costs and benefits of economic reform are distributed across the community and over time. For instance, the Commission's research on housing examines the socioeconomic impacts of policies to improve housing affordability. It is also concerned with the environmental impacts of economic activity. This ensures its focus is broader than merely economic productivity, as measured in market activity.

The Commission regularly engages with stakeholders to ensure its research and recommendations are well-informed. Its goal is 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.

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Abbreviations and glossary

ACCU	Australian Carbon Credit Unit
AEMC	Australian Energy Market Commission The AEMC is the main rule-maker for Australian electricity markets.
AEMO	Australian Energy Market Operator AEMO manages electricity and gas systems and markets across Australia, including the National Electricity Market.
CER	(Australian) Clean Energy Regulator
CO_2-e	Carbon dioxide equivalent The CO_2-e measure is used to compare various greenhouse gases based on their global warming effect. For instance, a tonne of methane has an effect on global warming equivalent to approximately 28 tonnes of CO_2.
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).
DNSP	Distributed network service provider A DNSP is an electricity distributor that owns and maintains an electricity network and its infrastructure, including power poles, wires, and transformers.
DPHI	(NSW) Department of Planning, Housing, and Infrastructure
DRI	Direct reduced iron This iron is created in a process which does not result in substantial greenhouse gases.
Electricity Infrastructure Roadmap	This is the NSW Government's 20-year plan for the electricity sector.
ESOO	*Electricity Statement of Opportunities* In this regularly updated AEMO publication, the market operator sets out the state of the electricity grid and electricity supply in the National Electricity Market.

EST	Energy Security Target This sets out the amount of reliable electricity that AEMO calculates is needed in New South Wales to meet maximum consumer demand.
Firmed renewables	These are variable renewable energy sources that are backed up by storage and peaking generation that can power the system when renewables generation is low.
IRM	Interim reliability measure
LCOE	Levelised cost of electricity
LTESA	Long-Term Energy Services Agreements These options contracts give generation investors the option to sell their output at an agreed minimum price, increasing investor certainty.
LULUCF	Land use, land-use change, and forestry
MAC	Marginal abatement cost In this paper, the MAC refers to the cost of removing the final unit of greenhouse emissions for a given technology.
Mt	Megatonne (one million tonnes)
NEM	National Electricity Market
NGERS	National Greenhouse and Energy Reporting Scheme
PDRS	Peak Demand Reduction Scheme This NSW scheme aims to reduce electricity demand at peak periods through incentives to businesses and households.
PV	Photovoltaic
REZ	Renewable Energy Zone
SMC	Safeguard Mechanism Credit
VPP	Virtual power plant VPPs are networks of behind-the-meter solar assets, such as batteries, that can be coordinated to work together like a power plant.

Executive summary

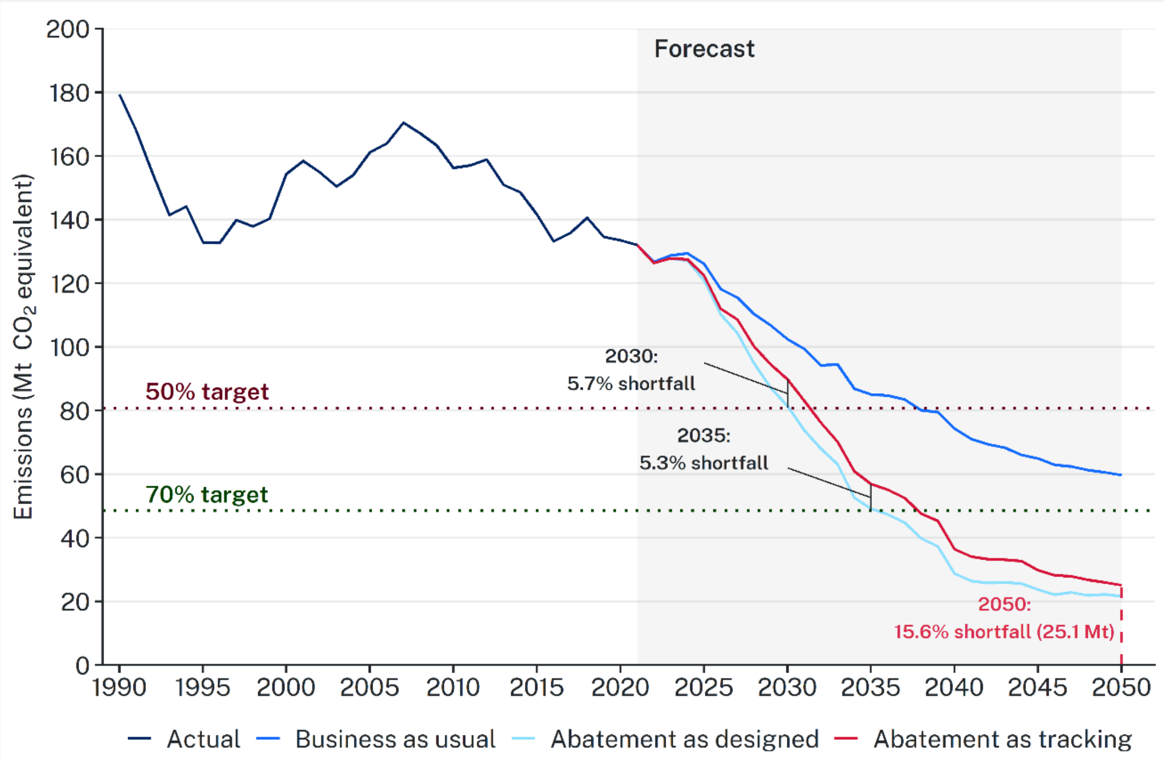
New South Wales needs policy change if we are to achieve our 2050 net zero target.

Main finding: we need more emissions reduction than we currently have planned.

New South Wales is gradually reducing greenhouse gas emissions.[1] Replacing coal with firmed renewables in the electricity system is among the easiest ways to cut emissions, and we are making progress.[2]

NSW's 2050 net zero target: the 25 megatonne shortfall

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



Source: (DCCEEW, 2024a).

Current progress isn't enough. Our legislated, bipartisan targets say that by 2030 we should cut emission by 50 per cent from 2005 levels, with cuts reaching 70 per cent by 2035. But the latest NSW Government projections find us falling short of both. Moreover, we are well off track for net zero by 2050.

[1] All figures for emissions beyond 2021-22 are projections – that is, they are simply our best guesses about how emissions will change under current Australian and NSW Government policies. The paper acknowledges these projections are accompanied by significant uncertainty.

[2] 'Firmed renewables' denotes variable renewable energy sources that are backed up by storage and peaking generation that can power the system when renewables generation is low.

Many activities need policy change to reduce emissions. They range from trucking, rail, aviation, and coastal shipping to domestic gas use, to fugitive emissions from coal mining, and methane emissions from agriculture. Carbon offsetting — such as 'rewilding' and direct-air capture — cannot absorb emissions at a level that would allow these activities to carry on.

The economic transformation required to achieve net zero by 2050 will, on current settings, **stretch the construction sector** beyond its capacity. With the high level of public infrastructure spending and the need for more housing supply, we lack the capital and skilled construction workers for all these tasks.

Many decisions that will determine the level of 2050 emissions involve long-lived capital items. Current policy settings are blocking that investment. So, to shape 2050 outcomes, **Australian governments must make decisions as soon as possible**. Decisions needed include:

- new incentives for private investment in near-zero-emissions manufacturing processes, heavy freight, and passenger transport
- clear signals about how we use natural gas
- decisions about the future of coal mining.

The longer we wait, the more it will cost us to fix the emissions shortfall. The easy decisions have already been made.

An inefficient net zero transition will have broad, negative equity impacts on the people of New South Wales. The most financially disadvantaged and socially marginalised groups would be hit the most.

Better market signals will help

New South Wales has no economy-wide price on emissions. Wherever possible, we should adopt price-based mechanisms to encourage efficient investment. The closest equivalent is the Commonwealth Safeguard Mechanism, but this has limited application to the state's emissions. The Electricity Infrastructure Roadmap and Capacity Investment Scheme are also reducing emissions in a relatively cost-effective way. They do not, however, explicitly price emissions.

A **comprehensive carbon dioxide-equivalent price** would provide households and businesses with a positive incentive to reduce their emissions wherever it is cheaper for them to do so. This would ensure abatement occurs at the lowest possible cost to the economy.

Prioritise electricity generation

All four remaining NSW coal generators are scheduled to close by 2040. The speed of our rollout of utility-scale renewables, firming capacity, and new transmission network infrastructure will largely determine whether we hit our targets for 2030. With a near-zero-emissions electricity system, we can lower emissions in other sectors by switching them to electricity in place of fossil fuels.

Maintain living standards through cost-effective policies

The scale of the changes needed underlines the need for policies to produce **the biggest possible emissions reductions for every dollar spent**.

If these changes are to happen, the prices we pay must reflect the costs we create. In electricity generation, this means supporting the emergence of a more digitalised electricity market where:

- more customers actively manage their electricity use
- prices reflect the full social and environmental cost of emissions and the need for reliability
- more customers have incentives to export energy to support efficient operation of the grid.

Further demand-side reforms in the electricity market will contain system costs, customer bills, and overall cost-of-living through the transition. This will be of particular benefit to lower-income earners.

The national challenge

Most of the principles and practical challenges discussed in our *Achieving net zero* series also apply to other Australian jurisdictions, including the Commonwealth. Australia signed the 2015 Paris Agreement, committing to the global goal of limiting the increase in the average global temperature to well below 2°C and pursuing ways to keep warming to less than 1.5°C. The Australian Government has legislated a target of net zero emissions by 2050, along with a 2030 target of a 43 per cent reduction on 2005 levels. Other states and territories have also legislated net zero for no later than 2050.

Summary of emissions sources

Electricity generation

46.6 Mt of CO_2-e in 2021, down from 58.1 Mt in 2005. Projected emissions in 2050: 2.8 Mt, or 11 per cent of total NSW emissions.

As coal-fired generators close, renewables will take over the vast majority of NSW electricity generation. Energy storage will ensure power can be dispatched to meet demand. This matters not just because it lowers emissions, but because the move to renewables will help other sectors to lower their own reliance on fossil fuels.

But the next steps will be challenging. We must:

- manage reliability and security risks as we experience large, 'lumpy' losses in capacity
- balance variable renewable energy with sufficient firming capacity such as storage and gas peaking generation
- ensure transmission network infrastructure comes online in time to link utility-scale renewables and storage into the system
- increase demand-side participation — through digitalisation, consumer energy resources, and cost-reflective pricing — to minimise system costs and risks to reliability.

Transport

25.2 Mt of emissions in 2021, up from 23.9 Mt in 2005. Projected emissions in 2050: 4.7 Mt, or 19 per cent of total NSW emissions.

Light vehicles like cars and utility vehicles will increasingly be electric. But emissions from rail, aviation, and shipping are all projected to rise, making the transport sector the third largest source of emissions by mid-century. Emissions reduction consistent with net zero by 2050 is unlikely without comprehensive carbon pricing.

Agriculture

19.4 Mt of emissions in 2021, down from 21.9 Mt in 2005. Projected emissions in 2050: 11.0 Mt, or 44 per cent of total NSW emissions.

While agricultural emissions have fallen in recent years, there are currently no commercially available technologies to drive significant further emissions cuts. By 2050, agriculture is projected to be the state's biggest source of greenhouse gas emissions, mostly methane emitted by cattle and sheep.

Fugitive emissions

11.0 Mt of emissions in 2021, down from 19.8 Mt in 2005. Projected emissions in 2050: 1.6 Mt, or 6 per cent of total NSW emissions.

These emissions depend heavily on coal mining activities and, therefore, on state licensing decisions.

Industrial processes and product use

13.0 Mt of emissions in 2021, down from 13.9 Mt in 2005. Projected emissions in 2050: 3.8 Mt, or 15 per cent of total NSW emissions.

Reducing emissions from the manufacture of materials such as steel, aluminium, and concrete depends on development of new, low-emissions processes. Electrification, energy efficiency, and green hydrogen will play important roles. But uptake will require broader and more ambitious emissions pricing.

Stationary energy

17.0 Mt of emissions in 2021, down from 17.4 Mt in 2005. Projected emissions in 2050: 5.0 Mt, or 20 per cent of total NSW emissions.

Stationary energy is projected to be the second largest emissions source by mid-century. Cutting emissions depends on getting homes and businesses off natural gas and reducing fossil fuel combustion in primary industries and manufacturing. Electrification, energy efficiency, and green hydrogen can help, but the size of cuts will depend on incentives, regulation, and the availability of skilled workers to retrofit existing buildings and alter processes.

Waste

4.0 Mt of emissions in 2021, down from 5.5 Mt in 2005. Projected emissions in 2050: 2.5 Mt, or 10 per cent of total NSW emissions.

Three-quarters of current waste emissions are due to solid waste disposal. Future waste emissions can be lowered by, among other methods, cuts in organic waste sent to landfill. Population growth, however, will put upward pressure on emissions. Achieving net zero will almost certainly require emissions pricing for the many small waste facilities in New South Wales.

Land use, land-use change, and forestry (LULUCF)

In 2050, LULUCF will contribute 6.2 Mt of CO_2-e abatement, or -25 per cent of total NSW emissions.

This sector has become a net reducer of emissions, contributing a 4.0 Mt cut in CO_2-e in 2021. The turnaround comes from a halving of emissions from land converted to grassland and cropland. Greater CO_2-e sequestration by plantations, natural regeneration, and regrowth on deforested land also contribute to emissions reduction.

1 Introduction

New South Wales has legislated a commitment to reduce net greenhouse gas emissions to zero by 2050. This paper sets out the policy challenges in meeting that target.

1.1 New South Wales has legislated greenhouse gas emissions targets

With the *Climate Change (Net Zero Future) Act 2023*, New South Wales legislated a target of net zero greenhouse gas emissions by 2050. All other Australian states and territories and the Commonwealth have adopted similar targets.

New South Wales has also legislated interim targets. They are a 50 per cent reduction from 2005 levels by 2030 and a 70 per cent reduction by 2035. Policies to support the interim target are set out in the NSW Government's *Net Zero Plan Stage 1 (2020-2030)* (DPIE, 2020).

The Commonwealth has legislated a target of net zero by 2050 and an interim target to reduce emissions by 43 per cent below the 2005 baseline by 2030. It submitted this target to the 2022 Conference of Parties as Australia's 'nationally determined contribution' under the 2015 Paris Agreement of the United Nations Framework Convention on Climate Change.

Box 1: What is 'net zero emissions'?

The term '**net zero emissions**' refers to achieving a balance between greenhouse gas emitted into the atmosphere and greenhouse gas removed from it. 'Net zero' means **we add no more greenhouse gas to the atmosphere than we take out.**

Eliminating gross greenhouse gas emissions seems unlikely in the foreseeable future. But net zero is much more achievable. It can be reached by offsetting residual emissions by absorption through carbon sinks, such as increases in forest cover and other vegetation.

What this paper does

This paper:

- profiles NSW greenhouse gas emissions in 2020-21, the most recent year of comprehensive data, in aggregate and by sector
- analyses the most recent NSW Government emissions projections to 2050 by source
- provides a policy framework to close gaps between emissions projections and targets in a way that is cost-effective for New South Wales
- applies that framework to the electricity sector.

Other sources of emissions — agriculture, buildings, manufacturing, mining, transport, and waste — will be examined in subsequent papers in the *Achieving net zero* series.

1.2 About NSW emissions data

This paper uses emissions projections

It is important to note that 'projections' are *not* forecasts.

An emission 'projection' is contingent on *assumptions about future trends*.[3] It does *not* imply that these assumptions are certain to be correct. A projection can provide a no-change baseline to judge the value of possible interventions. However, we know that circumstances, policies, and outcomes will change. But we do not know exactly *how* they will change.

In contrast, a 'forecast' is an outcome that is estimated will happen in the near term with a high level of probability, subject to a specific margin for error. This methodological definition means forecasts beyond the near term are not possible.

How New South Wales makes emissions projections

In April 2024, the NSW Government's Net Zero Emissions Modelling Program published updated projections for the state's greenhouse gas emissions to 2050.[4] The projections allow policymakers to identify gaps between targets and the outcomes that current policies are expected to achieve. They also guide further policy design that will allow those targets to be hit.

In this paper, as with national greenhouse gas accounting, we focus on scope 1 emissions produced in New South Wales. Scope 1 emissions are produced by economic units from sources that they own or control.

The NSW Government scope 1 projections include three scenarios that are used to illustrate potential future outcomes:

- the 'business as usual' scenario
- a 'current policy – abatement as designed' scenario
- a 'current policy – abatement as tracking' scenario.

Section 2.2 below defines these scenarios in detail, including the assumptions used.

1.3 Australian and NSW targets and the Paris Agreement

Reaching net zero emissions by 2050 in advanced economies may not be consistent with global temperature targets adopted under the Paris Agreement. The United Nations Secretary General, echoing calls from the scientific community, has called for advanced economies to achieve net zero emissions by as close to 2040 as possible (United Nations, 2023). This would support an even chance of holding the global average temperature increase to 1.5 degrees Celsius.

[3] See, for instance, 'Estimate and projection' from the Australian Bureau of Statistics (2024).

[4] The data is available at the NSW Net Zero Emissions Dashboard: https://www.seed.nsw.gov.au/net-zero-emissions-dashboard.

The Commonwealth Safeguard Mechanism, Capacity Investment Scheme, and New Vehicle Efficiency Standard will contribute to national emissions falling by a projected 42 per cent below 2005 levels by 2030. The Commonwealth expects to announce its 2035 target in 2025, in line with Australia's Paris commitments.

2 Emissions to mid-century: projections versus targets

Even large projected reductions in electricity and light vehicle emissions will leave us well short of the state's 2050 net zero target.

2.1 NSW greenhouse gas emissions have been steadily declining

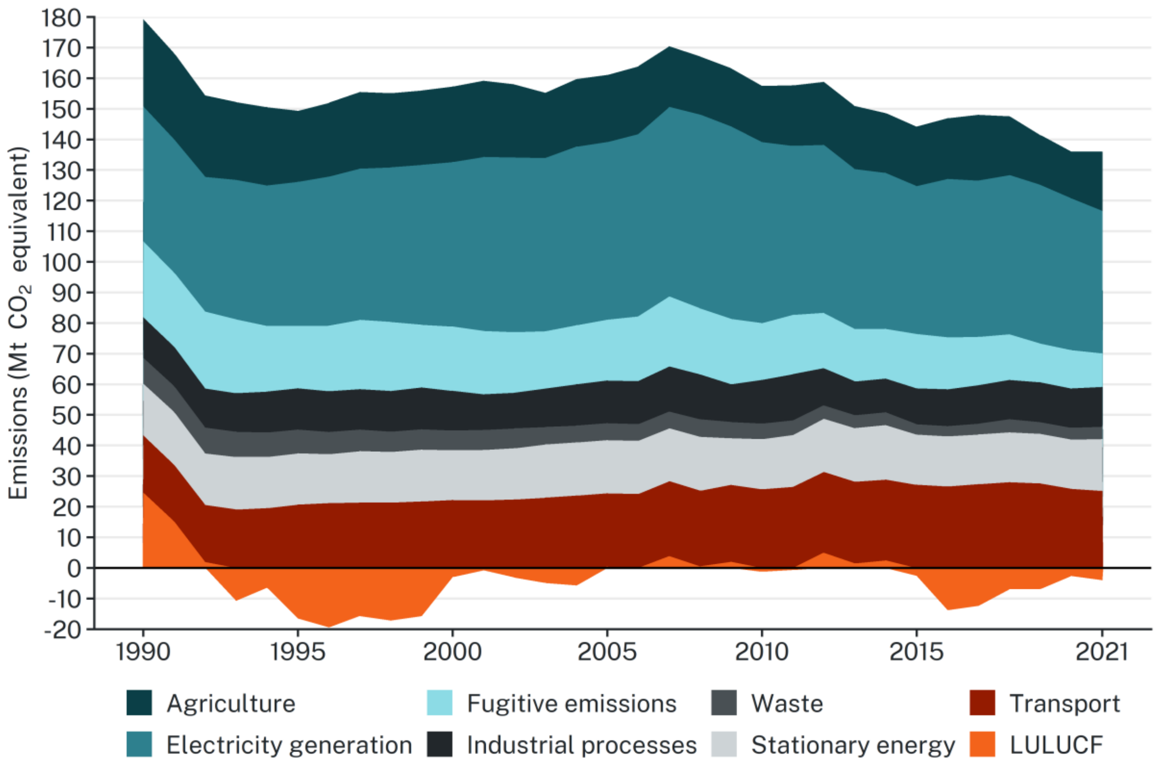
Total NSW emissions

Greenhouse gas emissions in New South Wales initially peaked at 179.4 megatonnes (Mt)[5] of carbon dioxide equivalent (CO_2-e) in 1990. Emissions gradually reduced somewhat in the years that followed, then peaked a second time at 170.5 Mt CO_2-e in 2007.

Emissions in 2005 — the baseline adopted by Australian governments — were 161 Mt CO_2-e. Since 2007, emissions have been steady or declining across all sources except transport, which has experienced consistent emissions growth.

Figure 1: Emissions have been slowly decreasing, mostly due to land use policy

NSW greenhouse gas emissions, total and by source, Mt CO_2-e, 1990-2021



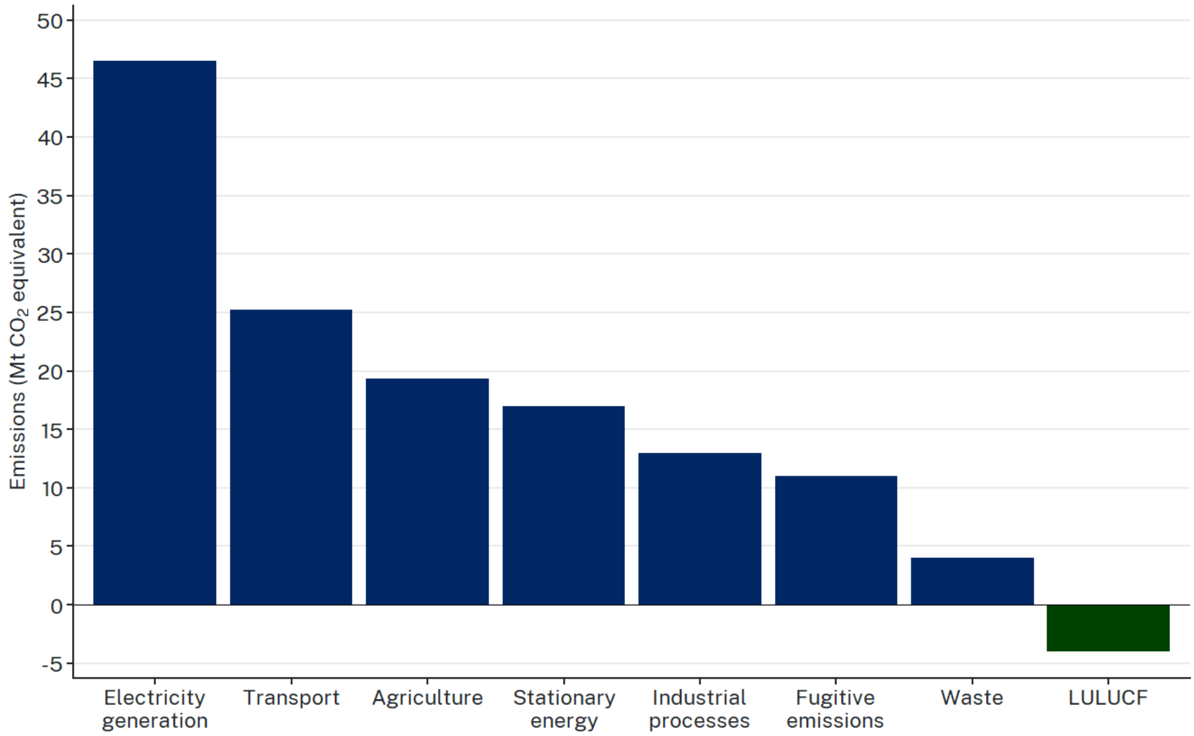
Source: (DCCEEW, 2024a).

[5] A megatonne is 1,000,000 tonnes.

In 2020-21 the state recorded net greenhouse gas emissions of 132 Mt CO_2-e – an 18 per cent reduction from 2005 levels.[6]

Figure 2: Electricity dominates current emissions, with transport a distant second

Components of NSW greenhouse gas emissions, by source, Mt CO_2-e, 2020-21



Note: While 2020-21 is the most recent year for which comprehensive NSW data is available, it took place during the COVID-19 pandemic, which changed consumption behaviours and slowed production processes.
Source: (DCCEEW, 2024a).

Emissions by greenhouse gas

Greenhouse gases vary by their ability to absorb infrared radiation – that is, their ability to trap heat from the sun. They also vary by the time they remain in the earth's atmosphere.

- Carbon dioxide (CO_2), the most common greenhouse gas in our atmosphere, can remain in the atmosphere for several hundred years.
- Methane (CH_4) is 25 times more potent at trapping heat than carbon dioxide but stays within the atmosphere for a much shorter time – seven to 12 years.
- Nitrous oxide (N_2O) is 298 times more potent than carbon dioxide and stays in the atmosphere for an average of around 120 years.
- Other, highly potent greenhouse gases that are released in very small amounts include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF6). These greenhouse gases are between 124 and 23,000 times more potent than CO_2 and last for hundreds to thousands of years in the atmosphere.

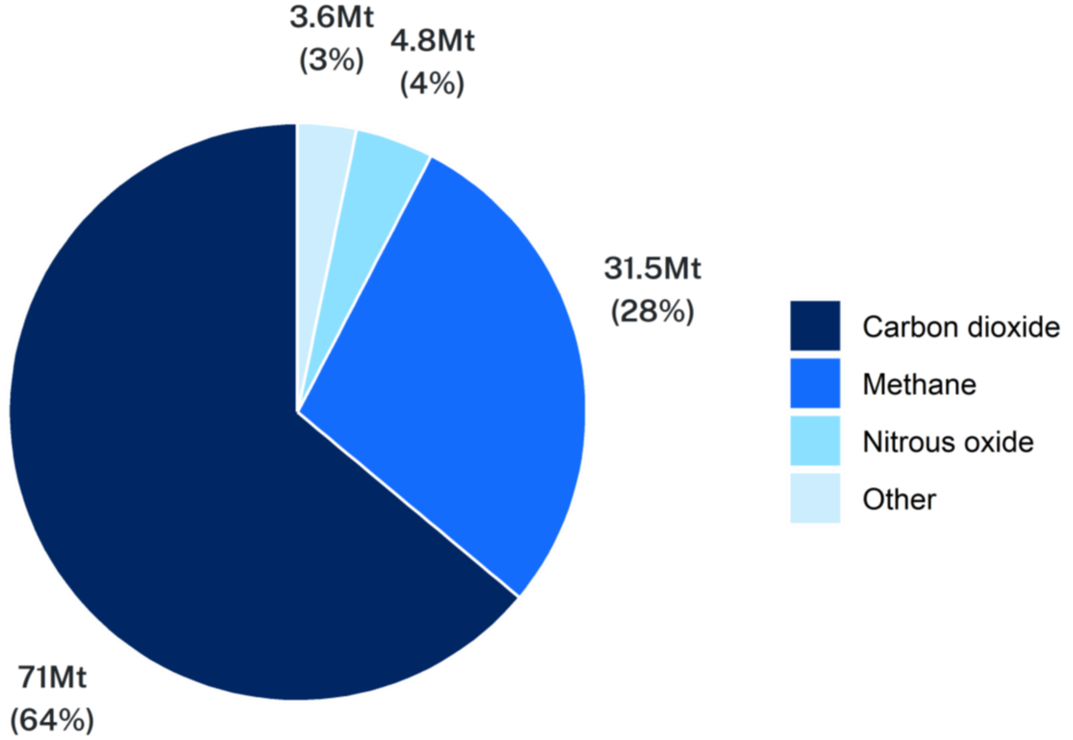
[6] 2020-21 is the most recent financial year for which detailed data is available.

We account for these differences by converting other greenhouse gases into their 'carbon dioxide equivalent' (CO_2-e).

Carbon dioxide accounted for 64 per cent of NSW emissions in 2021-22. These emissions came overwhelmingly from electricity generation, transport, stationary energy, and industrial processes. Methane accounted for 28 per cent of NSW CO_2-e emissions, primarily from agriculture, fugitive emissions, and waste. Nitrous oxide comprised roughly four per cent, with the remainder a combination of gases emitted in small quantities.

Figure 3: Carbon dioxide the largest category of greenhouse gas emissions, with methane second

Net CO_2-equivalent greenhouse gas emissions NSW 2021-22, share by gas



Note: Other includes PFCs, HFCs, and SF6.
Source: (DCCEEW (Commonwealth), 2024).

2.2 We are not on track to hit our legislated targets

The April 2024 update to the NSW Net Zero Emissions Dashboard presented three scenarios for how emissions might evolve over time under different conditions:

- The '**business as usual**' scenario accounts for past State policies but *excludes* any impacts from the *NSW Net Zero Plan Stage 1: 2020-30*.
- The '**current policy**' scenario took the 'business as usual' scenario and adjusted the emissions trajectory based on the designed abatement and timelines in existing NSW and Commonwealth policies, including:
    - policies under *NSW Net Zero Plan Stage 1: 2020-30*
    - future emissions reduction policies supported by the NSW Climate Change Fund under Stages 2 and 3 of the *NSW Net Zero Plan*

- the Australian Government's 2023 Safeguard Mechanism reforms.

'Current policy' is then split into two scenarios:

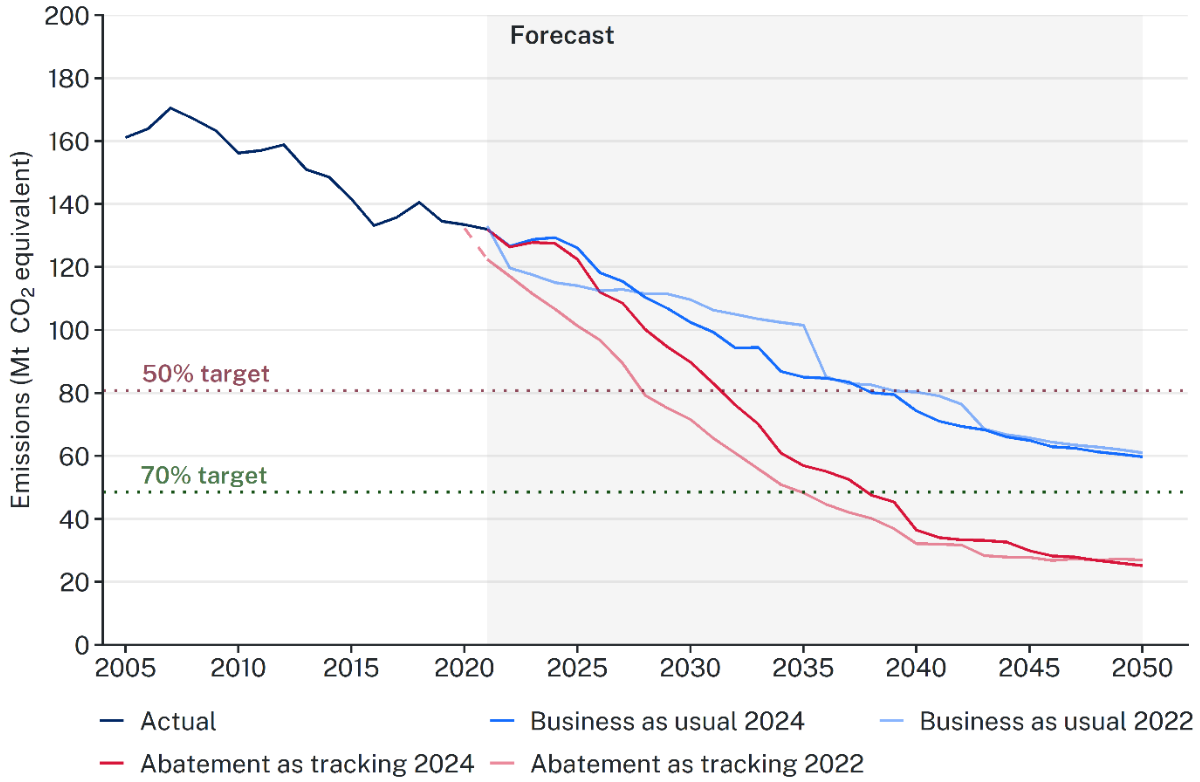
- the '**abatement as designed**' scenario adjusts the business-as-usual scenario based on the designed abatement and timelines in existing NSW and Australian Government policies and programs
- the '**abatement as tracking**' scenario adjusts the 'as designed' scenario to reflect increased uncertainties in expected emissions reductions under certain programs and policies.

This paper concentrates on the 'current policy – abatement as tracking' scenario (hereafter shortened to 'abatement as tracking'). NSW Productivity and Equality Commission analysis finds this the scenario most relevant to discussion of additional policy measures.

Figure 4 shows the projected emissions projections for each of these scenarios, together with historical emissions from 2000 to 2020. It also indicates emissions projections from the previous round of estimates, published in 2022.

Figure 4: The 2024 updated projections are less optimistic for emissions reduction

Actual and projected NSW greenhouse gas emissions under 'abatement as tracking' scenario



Source: (DCCEEW, 2024a).

The 2024 projections update shows a deterioration in our path to net zero in both the 'business as usual' and 'abatement as tracking' scenarios (Figure 4). That is, abatement is expected to proceed more slowly than expected. Smaller projected falls in emissions over the next 25 years can be measured by sector and are largely attributed to changes in projected energy consumption. This means **reaching net zero will now require more change in the time still available to 2050**.

Emissions from electricity generation are now projected to be, on average, 3 Mt higher every year until 2050. This is a result of higher projected electricity demand and lower renewable penetration. (This increase in emissions does not include the extension of Origin's Eraring coal-fired power plant for up to four years to 2029.)

Stationary energy emissions are also projected to be 3 Mt higher, on average, every year until 2050 because of slower assumed rates of fuel switching and electrification.

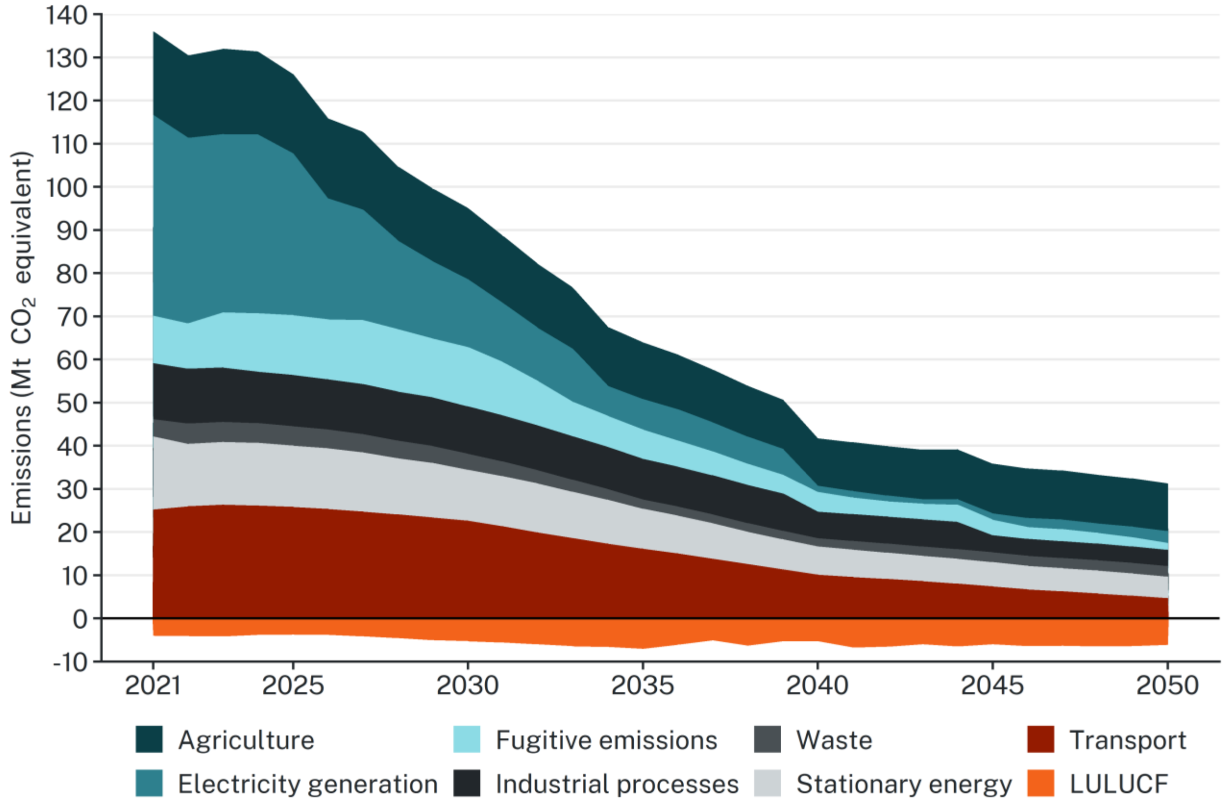
The rate at which land use, land-use change, and forestry (LULUCF) sequesters emissions is also projected to be lower until 2040. Emissions from grassland and cropland are as previously projected, but projected emissions from forested-land sinks have dropped.

Industrial process and product use emissions are projected to be between 1 and 4 Mt higher every year until 2045. This is because of higher projected output and higher emissions from chemical processes.

Fugitive emissions, and emissions in the agriculture, transport, and waste sectors are largely unchanged between the 2022 and 2024 projections.

Figure 5: Agriculture will be the biggest source of emissions by 2050

Projected NSW greenhouse gas emissions under 'abatement as tracking' scenario



Source: (DCCEEW, 2024a).

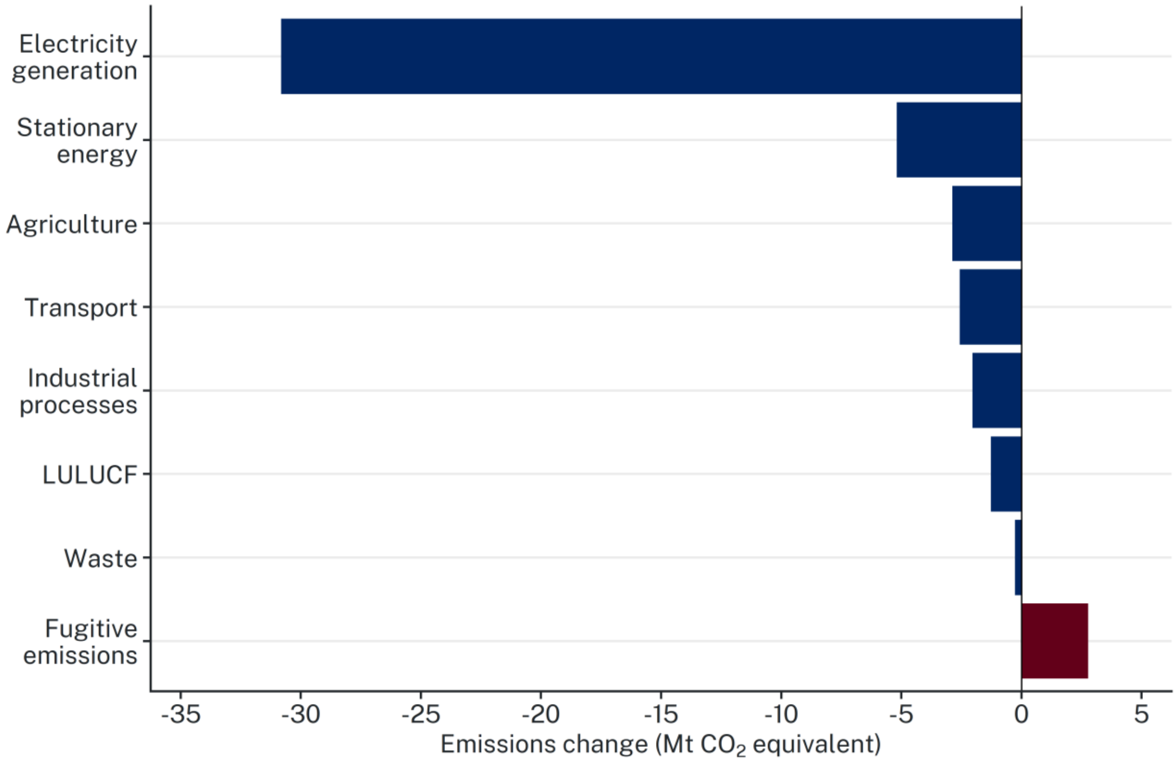
We are not on track for our 2030 target

By 2030, under the most likely scenario ('abatement as tracking'), NSW emissions are projected to have fallen to 90 Mt CO_2-e – a 44 per cent reduction from their 2005 level. This abatement is largely driven by changes in electricity generation. Coal generators are replaced with utility-scale renewables, firming capacity, and consumer energy resources (particularly rooftop solar and, increasingly, home batteries). The final thermal coal generation unit at Liddell closed in April 2023. Origin's Eraring generator, Australia's largest power station, is now scheduled to close no later than April 2029. More modest abatement is also projected for stationary energy, industrial processes, agriculture, and transport.

Projected abatement has fallen since the 2022 projections, when the State was projected to be 56 per cent below 2005 emissions in 2030. Along with higher electricity demand, this is also attributable to the extension of Vales Point Power Station's operations from 2029 to 2033. (This notification update was given by its owner, Delta Energy, to the market operator in 2022.) Continued operations are, however, contingent on the facility complying with stricter air and water pollution standards applied by the NSW Environment Protection Authority. It would also likely require a licensing extension of the adjacent Chain Valley coal mine.

Figure 6: What reduces emissions up to 2030?

Projected changes in emissions between 2021 and 2030, by source, in Mt CO_2-e, under 'current policy – abatement as tracking' scenario

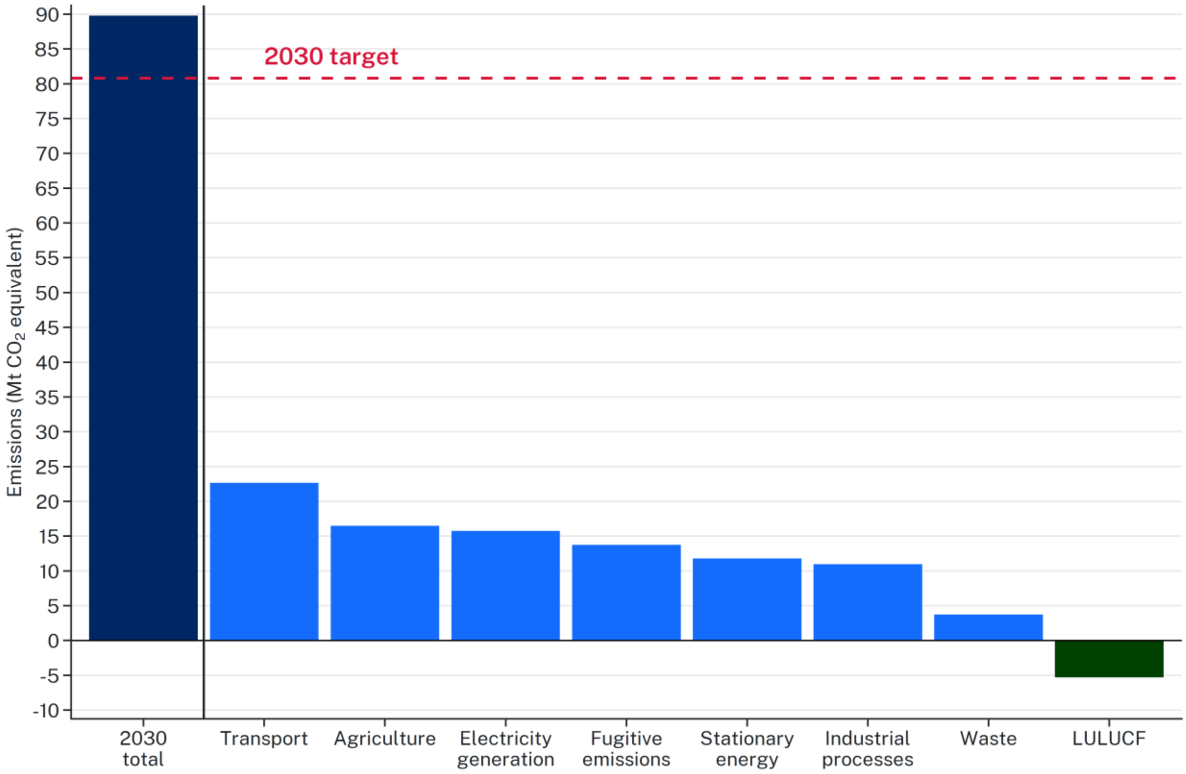


Source: (DCCEEW, 2024a).

Transport and agriculture are, nonetheless, projected to surpass electricity to become the two largest emissions sources by 2030, with only modest abatement projected for these activities. Emissions in stationary energy will be lower thanks to energy efficiency improvements and fuel switching from gas to electricity.

Figure 7: We are now projected to fall short of our 2030 target

Projected emissions components for 2030, by source, in Mt CO_2-e, under 'current policy – abatement as tracking' scenario



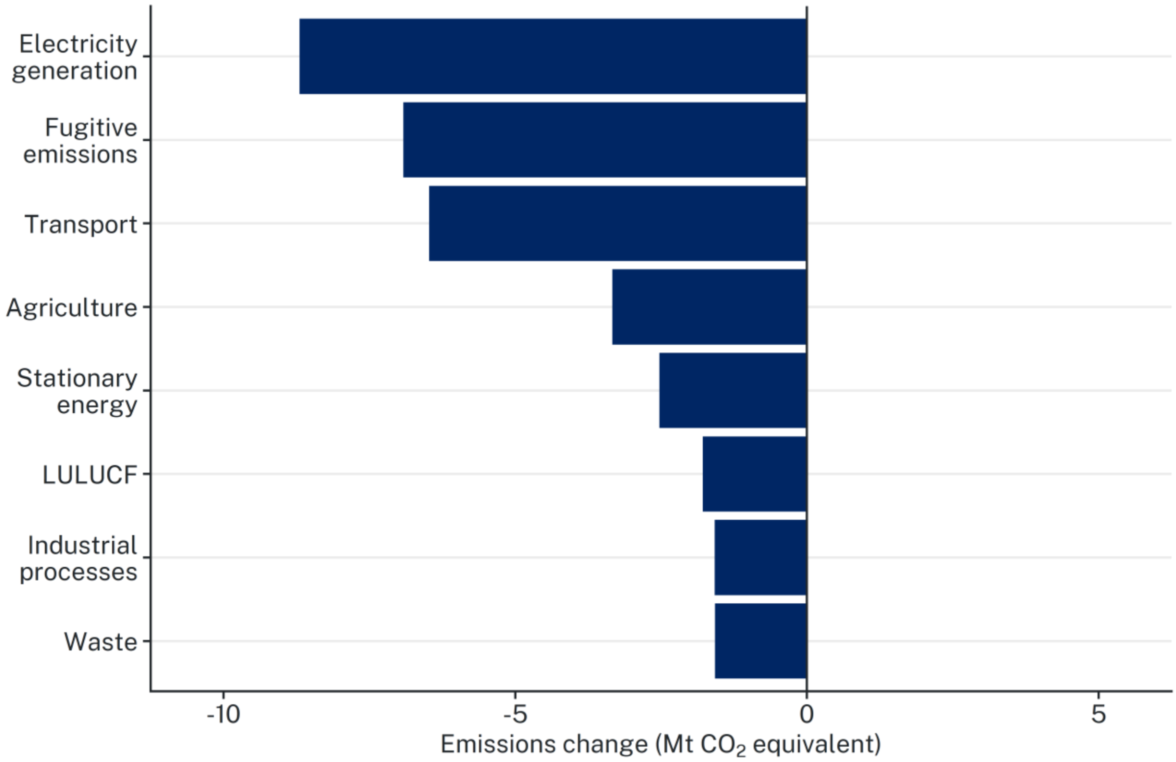
Source: (DCCEEW, 2024a).

2035 projections

Emissions will continue to fall beyond 2030, again driven mostly by abatement in the electricity sector. This will overwhelmingly be achieved by the closure of both the Vales Point B and Bayswater power stations, leaving just Mount Piper operational beyond 2033. The second area of progress is in fugitive emissions, with large projected falls because of reduced coal mining activity. Light electric vehicle uptake will also help drive abatement in transport.

Figure 8: Less coal, more electric vehicles drive abatement beyond 2030

Projected change in emissions between 2030 and 2035, by source, in Mt CO_2-e, under 'abatement as tracking' scenario



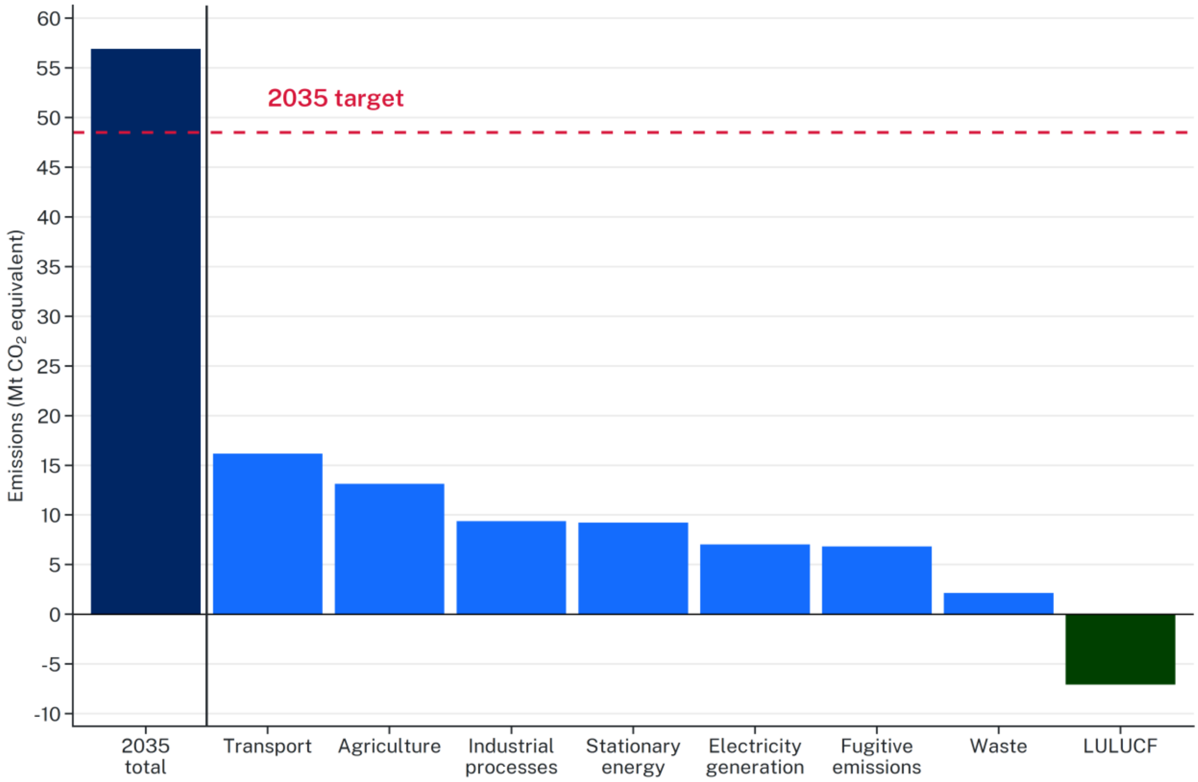
Source: (DCCEEW, 2024a).

Nevertheless, the State is still projected to miss its legislated 2035 emissions target of a 70 per cent reduction below the 2005 level – no more than 48 Mt CO2-e total emissions. Emissions are projected to be 65 per cent below 2005, or 57 Mt CO2-e. This is more modest progress than the 70 per cent reduction projected in 2022.

By 2035, transport is projected to be the largest emissions source, at 16 Mt CO2-e, or 28 per cent of total emissions. This is followed by agriculture, emitting 13 Mt CO2-e, or 23 per cent of total emissions.

Figure 9: We also expect to miss our 2035 target

Projected emissions components for 2035, by source, in Mt CO_2-e, under 'abatement as tracking' scenario



Source: (DCCEEW, 2024a).

2050 projections

No one can predict accurately the course of technological change over multiple decades. Internationally, cost reductions for renewable energy have confounded expectations. But there is no guarantee these trends will continue without action. Moreover, prices in global and domestic construction markets can be subject to significant shocks, pushing costs up and delivery timelines out.

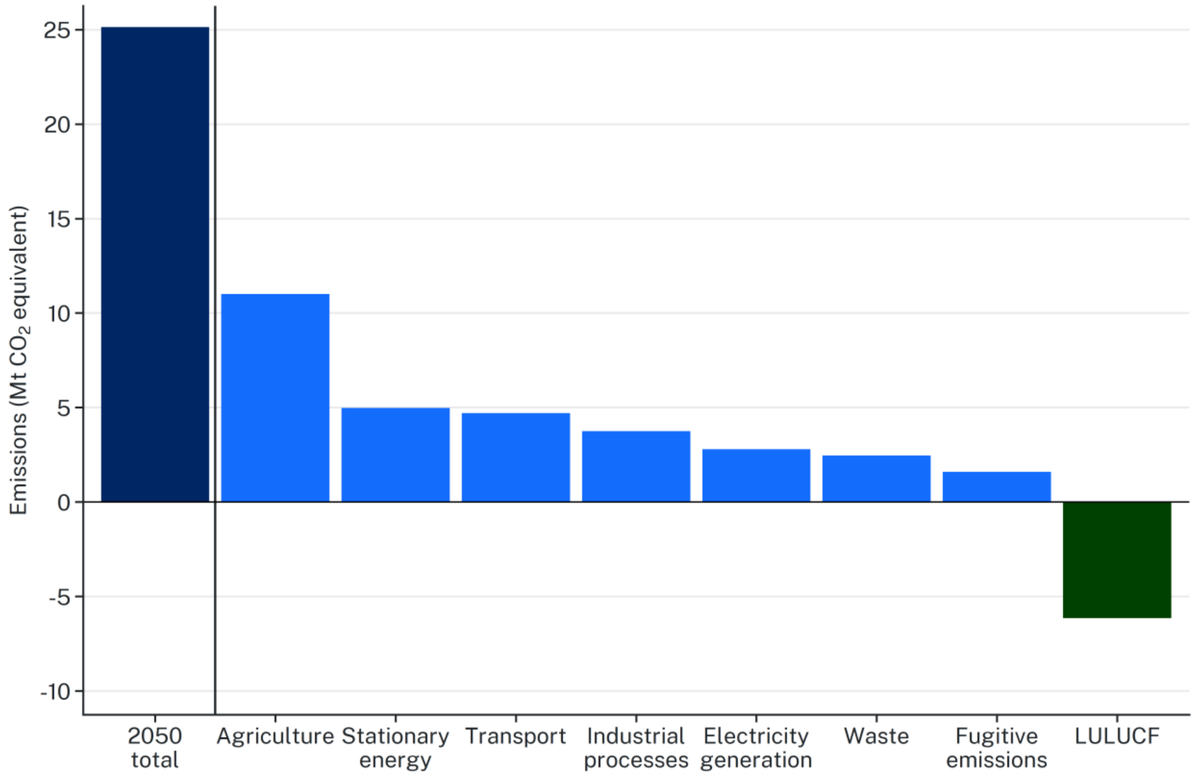
As of 2024, more global emissions are priced than ever before – 23 per cent, according to the World Bank (2023). Substantial public subsidies are now provided for investment in renewables and for research and development. But it is hard to project how these policies will induce further innovation and economies of scale in zero-emissions technologies.

Projections beyond the medium term — that is, after 2035 — should, therefore, be treated with caution. They, nonetheless, paint a cautionary picture of risks to achieving a net zero outcome if we don't have cost-effective policies to drive it.

The 'abatement as tracking' scenario projects 25 Mt CO_2-e will be remaining in 2050. Agriculture — primarily methane emitted by cattle and sheep — is projected to be the largest emissions source by mid-century, at 11 Mt CO_2-e, or 44 per cent of total emissions. Stationary energy is now projected to be the second-largest emissions source because of slower rates of fuel switching and electrification.

Figure 10: A lack of comprehensive policies means significant emissions are projected for 2050

Projected emissions components for 2050, by source, in Mt CO_2-e, under 'abatement as tracking' scenario



Source: (DCCEEW, 2024a).

Transport emissions are projected to fall as light electric vehicle adoption becomes widespread. But significant emissions would continue because heavy passenger and freight transport — aviation, rail, road, and shipping — continue to be dependent on fossil fuels. Zero-emissions technologies are projected to expand in industrial processes and product use but not by enough to eliminate emissions. Meanwhile, electricity emissions continue because of the use of gas generation as a firming technology.

Australian Government emissions projections

Achieving net zero is a national challenge. The Australian Government's November 2023 emissions projections track progress toward the *Climate Change Act 2022* (Commonwealth) interim target of 43 per cent below 2005 by 2030 and a cumulative carbon budget. Projections only extend to 2035.[7]

In these projections, the 'baseline' scenario accounts for those current Commonwealth and state policies that were in place at the time of publication. These include the 2023 changes to the Safeguard Mechanism, progress to date on the NSW Electricity Infrastructure Roadmap, and renewable energy targets in Victoria and Queensland. The Commonwealth's baseline scenario projects a 37 per cent emissions reduction below 2005 levels by 2030 and 49 per cent by 2035.

[7] Australia's Nationally Determined Contribution for that year – a quantity defined in the Paris Agreement – is to be set in 2025.

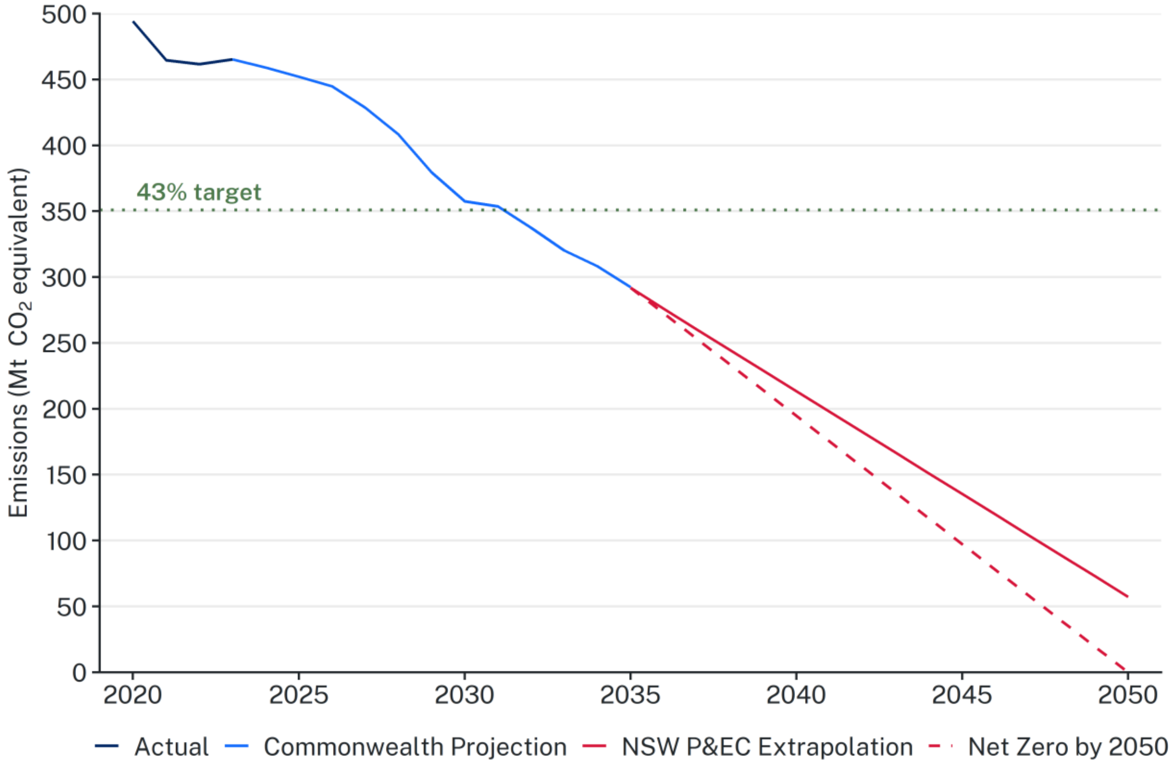
The more ambitious 'with additional measures' scenario includes new policies not fully designed or implemented. The main component is a future round of the Capacity Investment Scheme (see Appendix B for further discussion), aimed at achieving 82 per cent renewable electricity generation (including storage) nationally. This scenario projects a 42 per cent reduction in emissions below 2005 levels by 2030 — nearly on target — and a 53 per cent reduction by 2035.

On average, the rate of abatement per year between 2023 to 2035 under the Commonwealth's 'with additional measures' scenario is 16 Mt CO_2-e. Continuing this pace beyond 2035 (Figure 11) suggests Australia would miss its net zero target by around 57 Mt. Conversely, achieving the 2050 target would require increasing abatement to 18 Mt CO_2-e per year beyond 2030.

Slower abatement in the medium term will increase pressure for action in the years closer to 2050 to achieve net zero. This would possibly require more expensive and disruptive abatement measures to be implemented later, with significant negative impacts on living standards.

Figure 11: Commonwealth projections suggest Australia's current rate of abatement is insufficient for net zero by 2050

National emissions projections to 2035 ('with additional measures'), extrapolated to 2050



Source: (DCCEEW (Commonwealth), 2024), NSW Productivity and Equality Commission calculation, 2024.

3 A cost-effective net zero transition

Without an economy-wide carbon price, we must rely heavily on second-best government policies to deliver on the state's emissions reduction targets.

Achieving our legislated emissions reduction targets at the lowest possible cost is one of the most important productivity challenges facing New South Wales. It requires replacement of significant amounts of our private capital stock and retrofitting of our public infrastructure. It also requires changes to our behaviours as consumers and our approach to land use.

If New South Wales is to meet its 2050 net zero target, we will need policies to accelerate the transition. Government needs to provide businesses with sufficient incentives to make timely investments in large, long-term assets stretching to 2050 and beyond. It must also incentivise households to adopt energy saving and zero emissions technologies – 'consumer energy resources'.

To maximise living standards through the transition, businesses and governments must prioritise and sequence abatement options, implementing those that are lowest cost per tonne of abatement first. This will be challenging. But the alternative — adopting a wait-and-see approach — poses larger challenges by:

- raising the probability that the State will miss its legislated targets
- increasing costs today, because businesses will require a higher return on capital to compensate for the prospect that investments they make now will be 'stranded' later if policies change.

Government should also bear in mind net zero by 2050 may not prove ambitious enough to deliver on the Paris Agreement's global temperature target of 'as close as possible to 1.5°C'. This target remains an ambition in international diplomatic forums:

- in Rome in 2021, G20 leaders agreed that countries must take meaningful action to keep the world from warming by no more than 1.5°C
- the Glasgow Climate Pact at COP26 in 2022 reaffirmed this goal.

There is no obvious, specific time by which New South Wales and the rest of Australia must reach net zero if the world is to meet a 1.5°C warming target. But the UN has suggested developed countries need to reach net zero by 2040 – a much more ambitious trajectory than at present. Some domestic stakeholders have urged even more ambition, with Climateworks proposing net zero by 2039 (Skarbek, Malos, & Li, 2023) and the Climate Council arguing for a 2035 date (Rayner, 2024).

For the time being, both the NSW and Australian Governments remain committed to existing emissions reduction targets. But the more ambitious global temperature targets under the Paris Agreement accentuate policy risk and uncertainty in the ongoing net zero transition.

3.1 Implications of policy risk and uncertainty for productivity in the net zero transition

Energy policy uncertainty limits productivity and lowers living standards

Uncertainty in climate-related energy policy can limit private investment. AEMO publishes its Australian energy sector Inputs, Assumptions, and Scenarios database once every two years (AEMO, 2024a). Its 2023-24 release illustrates how the trajectory of climate policy has a causal relationship to the level and pace of technological change, costs, demand, and demand-side engagement.

Costs of firmed renewables and other zero-emissions technologies have fallen substantially (Graham, Hayward, Foster, & Havas, 2024). Yet this is not sufficient to drive structural change consistent with state and national targets. Insufficient clarity on how targets will be achieved adds risk and uncertainty to private sector activities. To compensate, investors must add a risk premium to the returns they demand. This effectively means investors are paying a 'shadow price' for carbon. But this shadow price is based on judgements that are different for each investor. They are also hidden from households and policymakers.

There are consequences of policy uncertainty creating a need for higher investment returns:

- **Projects do not happen.** Some proposals will now simply not reach the minimum rates of expected return needed for approval, reducing overall investment.
- **People are less productive.** Because smaller investment flows leave the economy with a smaller future capital stock, the capital-labour ratio will be lower than it would have otherwise been. With less capital to work with, labour productivity is lower.

Box 2 shows an example of how uncertainty affects investors.

Box 2: How policy uncertainty cuts investment and productivity

Investor A (a 'first mover') is ready to make significant investments in renewable energy and storage. It anticipates the energy transition will be relatively fast, so expects large medium-run payoffs from these investments.

Investor A is factoring a large shadow carbon price into its investment decision.[8]

Investor B anticipates the energy transition to be slower and bumpier than projected by Investor A. It makes small maintenance investments now to extend the useful life of its fossil fuel assets, ensuring they are profitable over the medium run. It defers more substantial investment in renewable energy.

Investor B is factoring a very low shadow carbon price into its investment decisions.

Investor C is 'risk averse'. It has tested a range of carbon prices and cannot identify one with a high degree of confidence as the basis for either new or maintenance investment decisions. It avoids *all* investment decisions now – either in new, zero-

[8] A *shadow carbon price* is an estimate of the internal cost of greenhouse gas emissions to a business' investment decision, factoring in expectations about the transition to a low-emissions economy.

emissions assets or maintenance of existing fossil fuels assets. Instead of investing, it will wait until policy circumstances become clearer. It lets existing assets run to the end of their useful lives.

In this scenario, only Investor A is making new investment decisions now. And, in the end, either Investor A or Investor B will have made the right strategic decision (but not both).

Each investor's situation changes when the government introduces a carbon price. The need for (varying) estimates of shadow carbon prices is removed for all firms:

- It confirms Investor A's earlier decisions, but also gives it the option to make further, similar investments, because the cost of finance no longer includes a premium for the risk of default.
- Investor B revises its strategy, as it now knows that maintenance investments will not yield the expected returns.
- It lowers the risk and uncertainty premium facing Investor C, which now decides to make significant new investment decisions that it had previously deferred.

Construction sector capacity will impact the cost and timing of the energy transition

The scale and scope of the energy transition should not be underestimated. It includes the need to plan and deliver:

- utility-scale renewables
- short- and long-duration storage (batteries and pumped hydro)
- new and upgraded transmission and distribution networks – including towers, substations, and poles and wires
- installations of consumer energy resources, including rooftop solar, home batteries, and smart meters
- electrification and insulation of existing residential and commercial premises
- installation of charging sites for both heavy and light passenger and freight electric vehicles
- electrification of agricultural, mining, manufacturing, and construction sites.

Each of these transformations will draw on the skills, construction materials, and capital equipment (including the freight network) available to our domestic construction sector. State and local governments also need other work from the same sector – to plan and deliver housing, major projects, and smaller infrastructure programs.

Housing has become a focus for all Australian governments. In 2023, the Commonwealth signed the National Housing Accord with the states and territories, committing to deliver 1.2 million well-located homes over five years to 2029. New South Wales has committed to delivering 377,000 dwellings as part of this task. The NSW Government also seeks to maintain housing supply momentum beyond the 2020s to keep a lid on housing costs and avoid further deterioration in affordability.

Public infrastructure requires significant resources. Australian governments are investing record amounts to build major road, rail, and energy projects. A large pipeline of projects in New South Wales is soaking up limited resources. Victoria has its own record infrastructure program, concentrated in large rail projects. The Queensland

Government had committed to significant public transport investments in south-east Queensland, while also pursuing a $62 billion 'Queensland Energy and Jobs Plan' but the future of the plan is uncertain.

Smaller projects to maintain minimum acceptable service levels in arterial and local roads, public transport, schools, and water will also demand construction sector resources.

Not everything can be built at once. Constraints in labour, materials, and equipment have been the subject of significant stakeholder commentary, as an overstretched construction sector suffers surging costs and delivery delays (Infrastructure Australia, 2023). Reports of delays and cost blowouts on major projects have become commonplace inside and outside of the energy sector. One prominent example is Snowy Hydro Limited's Snowy 2.0 pumped hydro project. All this activity is raising costs for both the public and private sectors, making prospective investments less feasible.

Decisions of the NSW Government can have a major impact — positive or negative — on how we use our resources. The State already has a record $119.4 billion capital program over the 2024-25 Budget and Forward Estimates period. This includes many commitments from the predecessor government that are high-risk, with value for money outcomes that remain unclear.

Capacity affects labour

The transition is facing challenges recruiting and retaining skilled workers because of this unprecedented pressure. Many tradespeople can move between infrastructure projects — energy, water, roads, freight, and public transport — and private residential, commercial, and industrial developments. Examples include earth movers, builders, concreters, electricians, boilermakers, heating, ventilation, and air conditioning technicians, plumbers, carpenters, bricklayers, and removalists. Box 3 highlights the transferable nature of trade certifications and skills for electricians.

This transferability is not limited to trades. Workers in professional roles such as engineering, architecture, and procurement are also able to move between construction subsectors. An energy project will necessarily compete for some of the same skilled people sought by public infrastructure and private development projects, whether in the trades or the professions.

Box 3: Transferability of electrical skills

The Clean Energy Council (2022), in its *Skilling the Energy Transition* report, explains that a Certificate III in Electrotechnology – Electrician qualification provides a preferred pathway into the renewable energy sector. This certificate is the same basic qualification that anyone seeking to work as an electrician in any sector must hold.

For example, a Transgrid electrical apprentice will receive training in the installation, inspection, maintenance, and repair of assets at a high-voltage substation. At the end of their apprenticeship, they will receive a Certificate III in Electrotechnology – Electrician. Holding this certificate and an appropriate licence is sufficient for emerging electricians to find employment across all subsectors. Specialised knowledge can be acquired on the job and/or through additional certifications.

Capacity affects materials

The continued, affordable supply of raw and refined materials and their efficient allocation is essential to the energy transition. Steel, concrete, copper, glass, and batteries are just some examples of the materials needed. New South Wales is not selfsufficient in the production of many of these materials and is exposed to volatile global supply chains and competitive domestic markets. The Berrima cement works, the state's only cement kiln, produces just 60 per cent of the cement used within New South Wales, with the rest imported from other states.

3.2 Pricing emissions is the best pathway

Today, market participants generate greenhouse gas emissions as they demand and supply goods and services. Those emissions impose a long-term cost on society through climate change. But this social cost is hidden from market participants, as it is not reflected in prices. By contrast, a carbon price creates signals for participants to produce and consume in ways that do not unduly cost society at large.

To ensure we hit our targets, policy would ideally impose a uniform constraint on greenhouse gas emissions. Consistent with our interim and long-run targets, we would allow the market to set a single, economy-wide price on carbon dioxide equivalent emissions.[9] This cost signal would be agnostic to the source of emissions and form of abatement.

Broad-based carbon prices give markets an incentive to abate emissions wherever the cost of abatement is lower than the price itself. Simultaneously, this approach induces:

- **behavioural change** by consumers, so that they buy less emissions-intensive goods and services
- **technological change** by businesses in favour of low- and zero-emissions production processes
- **innovation** by both the public and private sectors to research and develop new ways of avoiding future carbon price liabilities.

A carbon price is a systemic remedy: it is taken into account in decisions all through the production and consumption chain. It is an impactor-pays approach: those who create the most greenhouse gas emissions pay the highest cost.

Box 4 outlines the three main mechanisms for pricing greenhouse gas emissions.

[9] The technical term is a carbon dioxide equivalent (CO_2-e) emissions price; hereafter 'carbon price' or 'emissions price'.

Box 4: Carbon pricing mechanisms

There are, broadly, three mechanisms available to governments to price carbon, all of which internalise the social cost of greenhouse gas emissions.

A **carbon tax** directly sets a fixed price on emissions. The amount of emissions that a carbon tax prevents depends on its level and how markets respond.

A **baseline-and-credit system** sets a maximum amount of emissions per unit of a business's output ('baseline'). Businesses that emit below their baseline earn 'credits', which must be purchased by businesses emitting above their baseline. Baselines decline over time to achieve abatement objectives. Businesses that continue to emit face rising costs, while businesses that increasingly abate enjoy rising revenues.

Emissions outcomes for both carbon taxes and baseline-and-credit systems cannot be predicted exactly. They can, however, be forecast with reasonable accuracy over time.

An **emissions trading 'cap-and-trade' system** caps the total level of emissions in covered sectors, issuing permits either through an auction or free allocation. Businesses can either change their technologies to avoid the cost of permits or purchase permits. Permits can also be traded between businesses as market conditions change.

Each of these approaches to pricing carbon ensures that the lowest-cost abatement opportunities are exploited first, either through consumer or producer decisions. Moreover, carbon pricing creates an incentive for businesses to undertake research and development. This creates profit-making opportunities as innovations can be patented and sold to other businesses.

NSW emissions are only partly covered by pricing mechanisms

Under the **Australian Carbon Credit Unit (ACCU) Scheme**, businesses, organisations, and individuals are paid to reduce their emissions via a competitive auction process. Activities that are eligible for ACCUs — subject to verification — include:

- energy efficiency improvements
- land-use changes ('carbon farming') and vegetation projects
- methane capture and destruction
- waste management projects.

Each ACCU earned by participants represents one tonne of CO_2-e stored or avoided. Participants can then sell these ACCUs to generate income.

In 2023, the Commonwealth Government implemented changes to the existing **Safeguard Mechanism** to manage greenhouse gas emissions from large industrial facilities. Emitting facilities already report annual energy demand and emissions to the Clean Energy Regulator via the National Greenhouse Gas Reporting Scheme (NGERS). Facilities reporting scope 1 net emissions of more than 100,000 tonnes CO_2-e annually have new compliance requirements under the changes. The electricity sector is treated separately – as a sector, rather than by facility.

The Safeguard Mechanism is a carbon pricing scheme of the baseline-and-credit type. Of 219 non-electricity generating facilities in Australia subject to the Safeguard Mechanism in 2022-23, 35 are in New South Wales (Clean Energy Regulator, 2024). These facilities extend across the mining, manufacturing, transport, oil, gas, and waste industries, and produce approximately 21 per cent of the state's emissions. Including the electricity sector, the Mechanism covers 60 per cent of New South Wales' emissions.

Baselines had originally been set based on historical emissions, generally at high levels. Under the 2023 reforms, baselines will ratchet down over time by 4.9 per cent each year until 2030. Facilities that emit under their baseline can generate Safeguard Mechanism Credits (SMCs), a tradeable financial product equivalent to one tonne of CO_2-e not emitted. Facilities that exceed their baseline must buy and surrender either one SMC or one ACCU for each tonne of CO_2-e above their legal limit.

NSW emissions covered by the Safeguard Mechanism will fall from an estimated 24 Mt CO_2-e in 2022-23 (the last full year before implementation) to 17 Mt CO_2-e by 2030. Post-2030 decline rates will be set in predictable five-year blocks, subject to updates to Australia's Nationally Determined Contribution under the Paris Agreement. Decline rates for 2030-31 to 2034-35 financial years are to be set by 1 July 2027.

The Safeguard Mechanism, as reformed in 2023, has a range of weaknesses:

- its baselines are generous, limiting the abatement task between now and 2030
- the high, sector-wide baseline for electricity emissions means individual facilities do not face a carbon price, limiting their incentive to abate
- its coverage is limited only to facilities with high emissions, so small- and medium-sized facilities do not face a price incentive
- it fails to include coke oven gas emissions from BlueScope's Port Kembla Steelworks
- it does not impute transport emissions, limiting abatement in the transport sector.

These design elements close off potentially lower-cost abatement opportunities.

The Commonwealth Productivity Commission made several recommendations to strengthen the Safeguard Mechanism in its 2023 *5-year Productivity Inquiry Report* (Productivity Commision, 2023a). Four that have not been implemented to date were to:

- lower the facility threshold to 25,000 tonnes of CO_2-e
- improve the efficiency of the electricity sector's coverage by applying baselines at the facility level or lowering the baseline substantially
- expand coverage of the transport sector by imputing downstream emissions to wholesalers
- ensure any previously covered facility that falls under the threshold remains covered.

The Australian Government has committed to a review of the Safeguard Mechanism in 2026-27. It has also, however, ruled out adopting further changes before the review beyond those implemented in 2023. This leaves open the possibility of state-based carbon pricing to reduce or eliminate gaps in coverage and provide the economy with broad-based abatement incentives.

3.3 Policy evaluation for emissions reduction

Piecemeal carbon prices as a 'second-best' solution

In the absence of an economy-wide carbon price, disparate policy interventions seem certain to continue. Each of these interventions incur a different, but measurable, cost of abatement per tonne of CO_2-e, even though these costs may not be explicitly set out. This approach means abatement will be more expensive than it would be under comprehensive carbon pricing.

Some policies help to abate emissions relatively cheaply even though abatement is not necessarily the principal objective of the policy. Tradeable certificates under state energy efficiency schemes, for example, carry an estimated implicit carbon price of $41 per tonne of CO_2-e. At the other end of the spectrum, the original NSW Electric Vehicle Strategy implied a carbon price of between $271 and $4,914 per tonne of CO_2-e (Productivity Commission, 2023b).

Policy evaluation through cost-benefit analysis

Cost-benefit analysis (CBA) is the preferred method for policy decision-making in infrastructure investment, regulation, and recurrent programs. The *NSW Government Guide to Cost-Benefit Analysis* (NSW Treasury, 2023a) requires a CBA for every capital, recurrent, and ICT proposal with an estimated total cost higher than $10 million.

Australian governments may decide to opt for mitigation policies other than carbon pricing. These should be evaluated via CBA. CBA should also be used to evaluate the impact of regulations that complement carbon pricing.

The cost of emissions — and the benefits of emissions reduction — should be included where their impacts are likely to materially affect the outcomes of the CBA. The NSW Government recently published a technical note on carbon values for use in cost-benefit analysis. The values were derived from a model of marginal abatement costs (MAC)[10] specific to New South Wales that were consistent with the state's emissions reduction targets.[11]

The Australian Energy Regulator (AER) has released guidance that includes a value of annual emissions reduction (VER) for use in Regulatory Investment Tests. This involves cost-benefit analysis of electricity network infrastructure investments. The AER values range from $70 per tonne CO_2-e reduced in 2024 to $420 by 2050 (AER, 2024).

But regulatory and expenditure interventions for the purpose of emissions reduction — even when evaluated via CBA — are considered a second-best approach to carbon pricing. The key limitations:

- Governments evaluate policy proposals on a case-by-case basis. For a given carbon value, this does not necessarily mean all cost-effective abatement options have been prioritised. By contrast, carbon pricing provides an incentive for all cost-effective abatement measures to be taken up.
- Cost estimates used in CBA can never be prepared from perfect information. Estimates inevitably carry errors. Technologies and their costs change over time,

[10] The cost of reducing the final tonne of CO_2-e using a particular solution.

[11] Carbon values are used in CBAs to value the cost of emissions and the benefit of reducing emissions stemming from policy proposals (NSW Treasury, 2023b).

sometimes significantly and rapidly (e.g. solar photovoltaics, wind turbines, and batteries). Ongoing abatement programs would have to be re-evaluated regularly to ensure they most accurately reflect the abatement landscape. But public agencies do not necessarily have the resources or the incentive to do this.

Carbon prices, by contrast, leave it to individuals, households, and businesses to determine whether it is cheaper to abate, based on the private information available to them.

3.4 Principles for navigating the world of the second-best

Without a broad-based carbon price, the burden falls on government to assess abatement costs right across the economy and then to prioritise and sequence interventions to achieve emissions reduction. This is a very difficult task that requires high levels of evidence and agility.

Several principles can help guide government decision-making:

1. We should prefer carbon dioxide equivalent pricing that replicates the Safeguard Mechanism and that allows acquittal of either tradeable SMCs or offsets under the ACCU program. This approach must be careful to avoid double-counting SMCs and ACCUs.
2. Should government decide not to price emissions from a particular activity, cost benefit analysis should be performed on policy proposals to reduce greenhouse gas emissions (NSW Treasury, 2023a). Any marginal abatement cost (MAC) forecasts used in these analyses should be up to date (DCCEEW, 2024b). Policymakers should carefully assess any risk of unintended consequences and take account of these risks in policy design.
3. Interventions should be technologically agnostic and competitively neutral.
4. Policy overlaps — where multiple policy interventions target the same objective — should be avoided, except where policies are clearly complementary. This will ensure compliance costs neither are unduly high nor distort incentives.
5. Whether the Australian or the NSW Government takes the lead in emissions reduction policies depends on which jurisdiction is both willing and best-placed to design and implement policy.

4 Electricity generation

The path to net zero in the electricity sector is well-defined, but New South Wales will need to navigate challenges to ensure reliability and affordability during the transition.

4.1 Technological costs and emissions scenarios

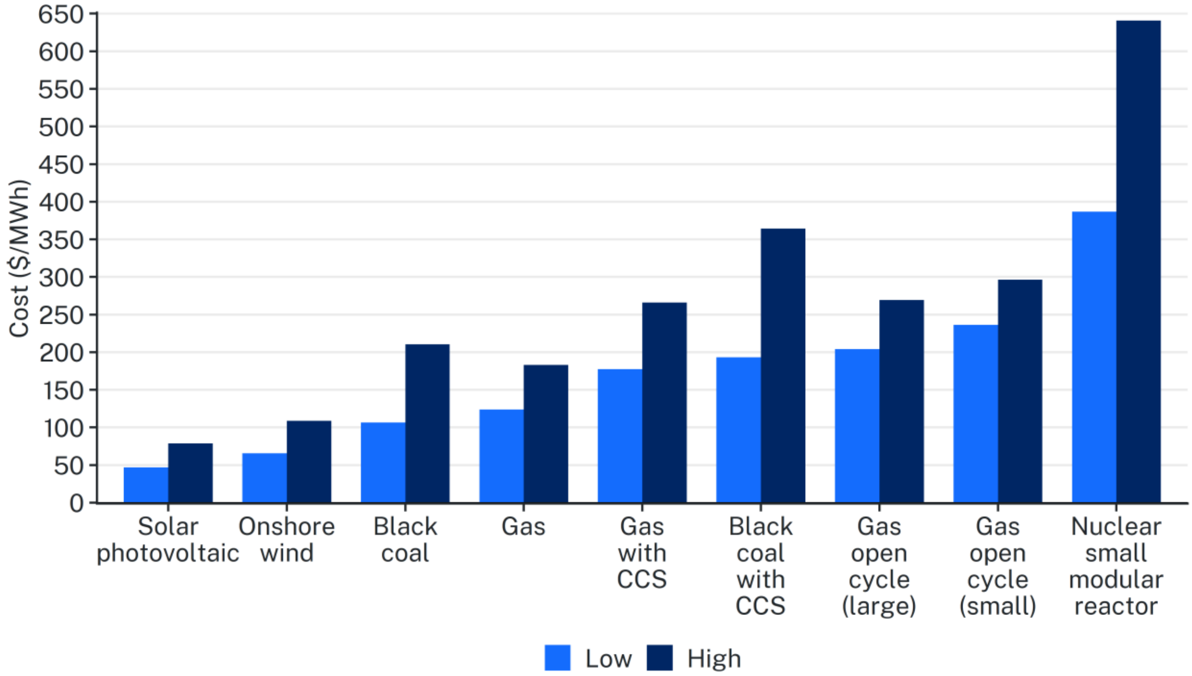
The cost of generation technologies

Renewables are the cheapest available source of electricity based on the CSIRO's *GenCost 2023-24* report (2024). The report estimated utility-scale solar photovoltaic (solar PV) and onshore wind turbines as having the lowest levelised cost of energy in Australia (Figure 12). In the best-case scenario for fossil fuels, black coal is estimated as more than twice as expensive per megawatt-hour as solar PV. When combined with carbon capture and storage technology (CCS), black coal is even more expensive. Small modular nuclear reactors (nuclear SMR) — the costliest technology modelled — were more than eight times more expensive as solar PV. The estimates include the cost of additional transmission and storage capacity to ensure a reliable electricity system.

The levelised cost of energy estimates for solar and wind are robust to a system dominated by renewables. Utility-scale solar and wind (complete with necessary transmission upgrades and additional firming capacity) are the lowest-cost new-build technologies. This holds even when solar and wind make up 90 per cent of the generation mix. This research also applies an additional risk premium to fossil fuel generation to account for the possible future application of a carbon price or some other restriction on emissions.

Figure 12: Solar and wind have the lowest levelised cost of energy

Levelised cost of energy (LCOE) by generation type in Australia, 2023-24



Note: The LCOE data presented are estimates based on different assumptions for capital costs, fuel costs, and capacity factors (such as generator utilisation). CCS is carbon capture and storage.
Source: (Graham, Hayward, Foster, & Havas, 2024).

The International Energy Agency has made similar findings for Australia.[12]

Electricity generation emissions scenarios

Emissions from electricity generation were 43 Mt CO_2-e in 2021-22, a decline of 15 Mt CO_2-e (26 per cent) from 2005 levels. As set out in section 2.2 above, the 'abatement as tracking' scenario in the NSW Net Zero Emissions Dashboard is considered the most likely scenario. It accounts for the announced generator closure dates as of mid-2024 and for NSW's Energy Security Target, Electricity Infrastructure Roadmap, and Energy Security Safeguard.

'Abatement as tracking' is more optimistic in the near term and less optimistic in the medium term for emissions reduction than AEMO's 'step change' scenario. The latter was considered most likely by stakeholders that gave feedback on AEMO's 2024 *Integrated System Plan* (Figure 13).[13]

Under both scenarios, emissions will drop rapidly over the next ten years as Eraring, Bayswater, and Vales Point B close as scheduled. By 2040, when the final coal-fired power plant, Mount Piper, is scheduled to close, electricity generation in New South Wales is projected to produce only 1.4 Mt of emissions. In 2050, electricity generation in

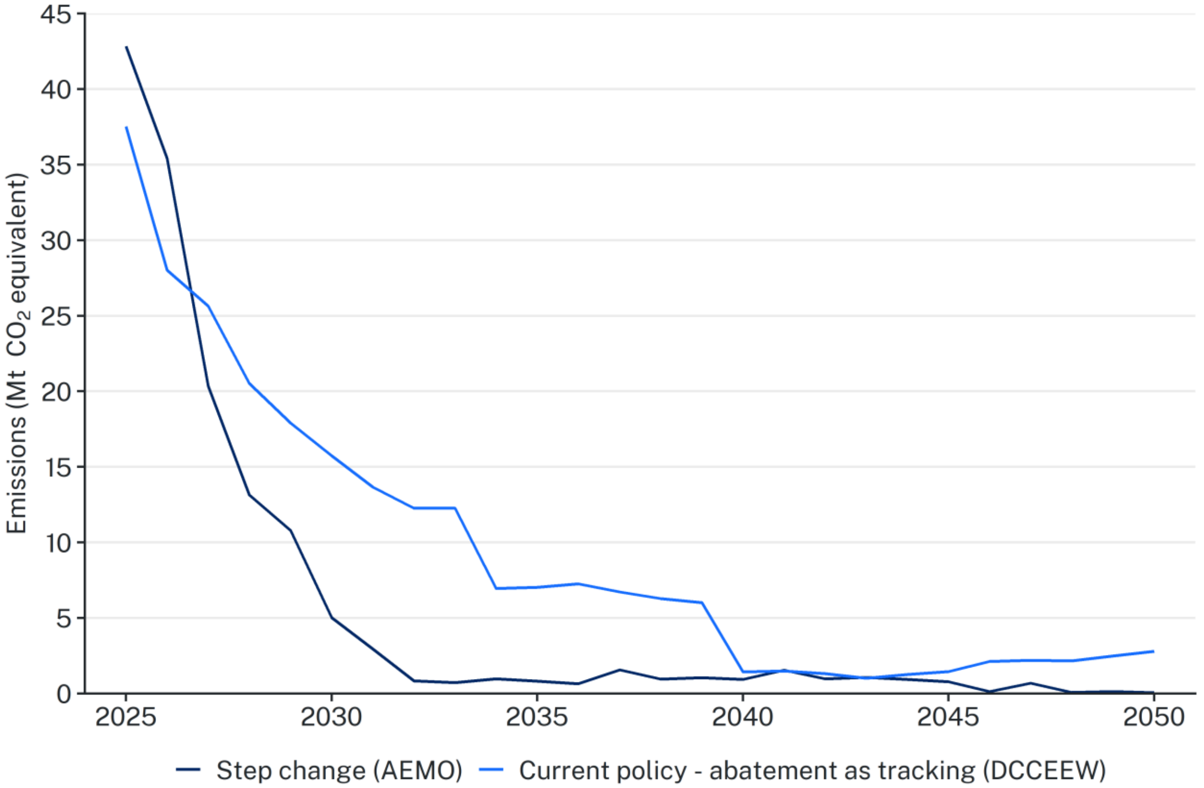
[12] This is based on a levelised cost of electricity calculator tool provided by the International Energy Agency. Assumptions included a discount rate of five per cent, a carbon price of zero, a heat price of $37.06 USD/MWh, and coal and gas prices at 100 per cent (International Energy Agency, 2020).

[13] The decision to support Origin's Eraring power station to remain open for an additional two years, until 2027, will increase the expected emissions of the NSW electricity system through to 2027. Neither the 'abatement as tracking' or 'step change' scenarios take account of Eraring's extension.

New South Wales is projected to produce 2.8 Mt of emissions — mostly from gas — and account for 11.1 per cent of total NSW emissions.

Figure 13: AEMO has projected a more optimistic path for NSW electricity generation emissions

NSW electricity generation emissions by scenario, 2025-2050



Source: (AEMO, 2024b); (DCCEEW, 2024a).

4.2 Challenges in the NSW National Electricity Market

The NSW electricity system is a region of the wholesale National Electricity Market (NEM), which also covers Queensland, Victoria, South Australia, Tasmania, and the Australian Capital Territory. The NSW region is dominated by coal-fired generation, which produced around 60 per cent of total electricity over 2023.

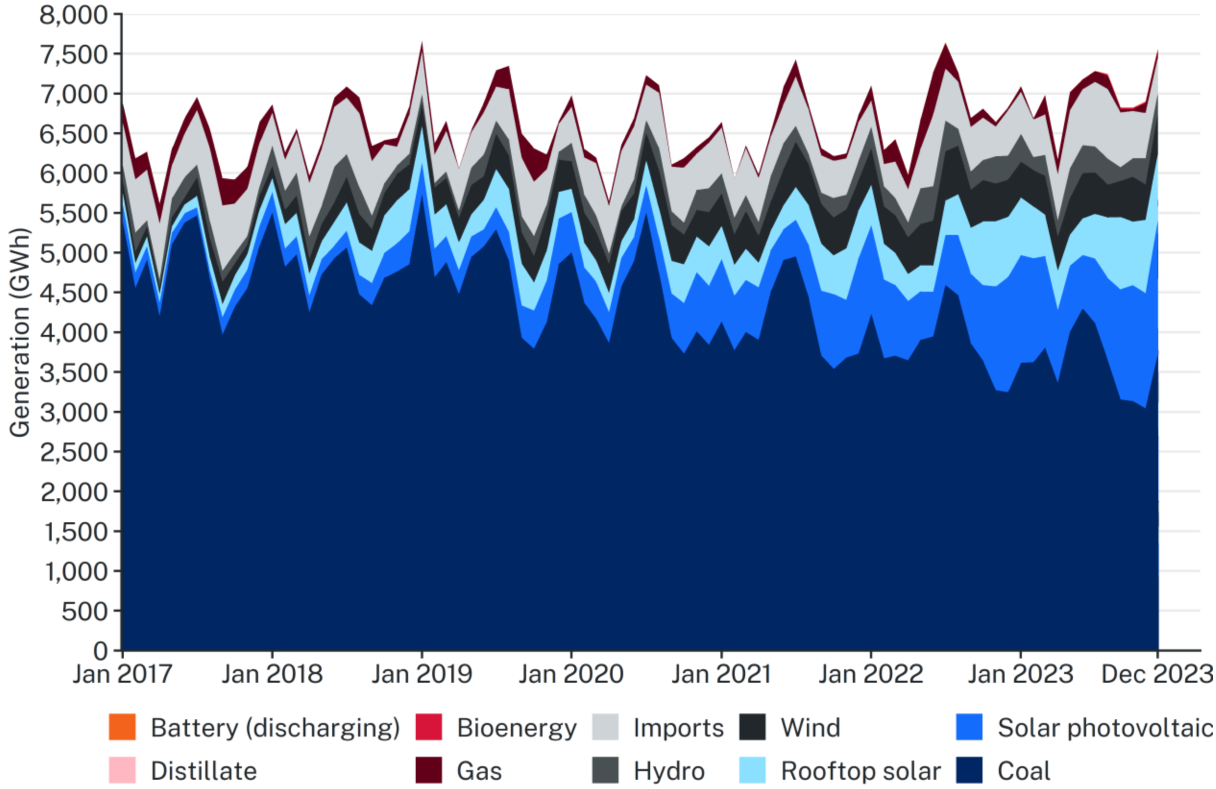
This share has diminished over the past decade. Wind and solar generation have slowly crept upward, initially thanks to policies such at the Commonwealth's Renewable Energy Target and, more recently, because of the falling costs of these technologies.

Meeting a minimum level of electricity reliability is essential to ensuring the transition to a net zero system does not unduly impact economy-wide productivity and living standards. But very high reliability comes with additional costs. Sufficient generation and firming capacity and new transmission and distribution network infrastructure are required to meet a reliability standard with a high level of confidence. This capacity, in turn, carries capital and operating costs, which are ultimately borne by customers.

In short, the higher the desired level of reliability, the higher the costs for electricity faced by consumers. During the transition, a balance must be maintained between reliability and the expected cost of reaching it.

Figure 14: Coal still generates most of our electricity, but its share is falling

Share of NSW electricity generation by technology, 2017-2023



Source: (AEMO, 2024c).

The transition in progress

Thermal coal generators, currently totalling 8.3 gigawatts of capacity, remain operational in New South Wales. But their retirements are being driven primarily by market forces:

- reduced **revenue** from 'stop-start' operations where coal-fired electricity is out-competed by variable renewable energy
- the age of assets increasing **maintenance costs**
- **falling reliability**, including unplanned outages
- increasing **operating costs** because of rising thermal coal prices.

The challenge for the net zero transition in electricity is to have enough replacement generation and transmission capacity online when coal power stations close. Under the NEM's original design, a step reduction in generation capacity prompts a sustained spike in NEM wholesale spot prices. This, in turn, feeds through to wholesale contract prices, signalling the need for investment. The NEM's governing bodies also provide information about when more capacity is needed. These include the NEM's register of intended generator closures and its 42-month notice of closure requirement.

Consumers reasonably expect policymakers to ensure a reliable electricity system during the net zero transition. The National Electricity Rules adopt a reliability standard requiring at least 99.998 per cent of forecast consumer demand is met each year. The 0.002 per cent maximum unserved energy is forecast and projected by AEMO through its annual *Electricity Statement of Opportunities*, with updates given after material changes in market conditions.

Presently, a more stringent 'interim reliability measure' (IRM) is in place until 30 June 2028 to maintain reliability during a one-in-10-year summer event and reduce the risk of load shedding in the NEM.[14] The IRM sets a lower benchmark of 0.0006 per cent of expected unserved energy demanded in any region per year. Exceeding the IRM can trigger the interim reliability reserve (an amount of out-of-market capacity that AEMO can procure in periods of high demand) and the retailer reliability obligation.

Overlapping this is the NSW Energy Security Target, legislated in 2020, which guides State interventions. The Energy Security Target (EST), adopted as the trigger for actions by the NSW energy minister, is set at:

- *capacity* needed to meet forecast NSW maximum consumer demand in summer (measured using a 10 per cent probability of exceedance) plus
- *a reserve* to account for an unexpected loss of the state's two largest generating units.

As of 2023-24, the two largest generating units in New South Wales were Mount Piper Power Station Unit 1 (MP1, with a 705 MW summer peak rating) and Eraring Power Station Unit 2 (ER02, with a 680 MW summer peak rating). (Further information on the EST and the Electricity Infrastructure Investment Roadmap is available in Appendix B and Appendix C.)

A test case for the transition: the Eraring extension

Both the NSW and Victorian Governments have displayed a willingness to intervene in previously privatised electricity generation markets. These interventions have aimed to extend the life of coal power stations and to smooth what these governments have perceived as hiccups in the transition. The effect is to contain wholesale prices and the signals these provide to market participants to make investment decisions.

Each intervention poses new issues for investor certainty, overall system costs, and the speed of the transition. This raises the question of whether expected or temporary gaps in supply can be filled in more strategic, cost-effective ways. These issues are illustrated by the prospect of extending the life of the Eraring Power Station (the 'Eraring extension'). This subsection explores that example.

Closing the Eraring gap

In February 2022, Origin Energy gave AEMO a 42-month notice of closure of its Eraring Power Station at Lake Macquarie, bringing forward its closure by seven years to August 2025. The NSW Government responded with an assessment of the state's ability to fill the resulting gap in power supply when Eraring closed. Among the measures to close the gap were the following:

- The NSW Minister for Energy directed Transgrid to be the network operator of the new 850 MW/1,680 MWh[15] Waratah Super Battery. This battery, at the site of

[14] Load shedding involves instances where demand exceeds supply to the extent that it poses a risk to system security.

[15] This designation signals that the battery can deliver 850 megawatts of power for almost two hours, providing a total 1,680 megawatt-hours of energy.

the former Munmorah Power Station on the Central Coast, was designed to ensure essential system services after Eraring's closure.

- Additional generation capacity would come from the growth of renewable energy — particularly rooftop solar — and greater use of peaking gas generation. Demand is also expected to be moderated through the Peak Demand Reduction Scheme.
- The Minister also issued a new 'firming' tender under the NSW Electricity Infrastructure Roadmap to meet the need for dispatchable capacity after Eraring's closure. The tender was later supported by the Commonwealth as the first phase of its new Capacity Investment Scheme.
- The tender results, announced in September 2023, totalled 1,075 MW of firm capacity. The successful project proposals were three battery energy storage systems and one demand response agreement:
    - Akaysha Energy's 415 MW/1,660 MWh (four-hour) **Orana battery** energy storage system
    - AGL Energy's 500 MW/1,000 MWh (two-hour) **Liddell battery**
    - Iberdrola's 65 MW/130 MWh (two-hour) **Smithfield battery**
    - Enel X Australia's combined three **virtual power plants** of 50 MW, 20 MW, and 25 MW (each with a minimum dispatch duration of two hours).

An enduring Eraring shortfall

Of the investment solutions to the Eraring gap, only the Waratah Super Battery remains on schedule at time of writing.[16] The Orana and Liddell batteries are delayed until 2026 and 2028, respectively. A 460 MW/920 MWh battery, announced by Origin for the Eraring site, is also being delivered, with AEMO modelling a 2026 commissioning date for the project.

AEMO cited the slippage of these key projects in the May 2024 update to its 2023 *Electricity Statement of Opportunitie*s, which had already forecast significantly greater system demand growth than in the prior year. The NSW reliability outlook deteriorated under the ESOO's conservative 'central' scenario because of revisions to demand distributions and project delays.

The market operator has a high bar for classifying investments as 'committed'. Under AEMO's definition, projects at an advanced stage of planning may still fail to qualify. They can, however, qualify as 'actionable and anticipated', ready for reclassification as 'committed' when investment decisions are made.

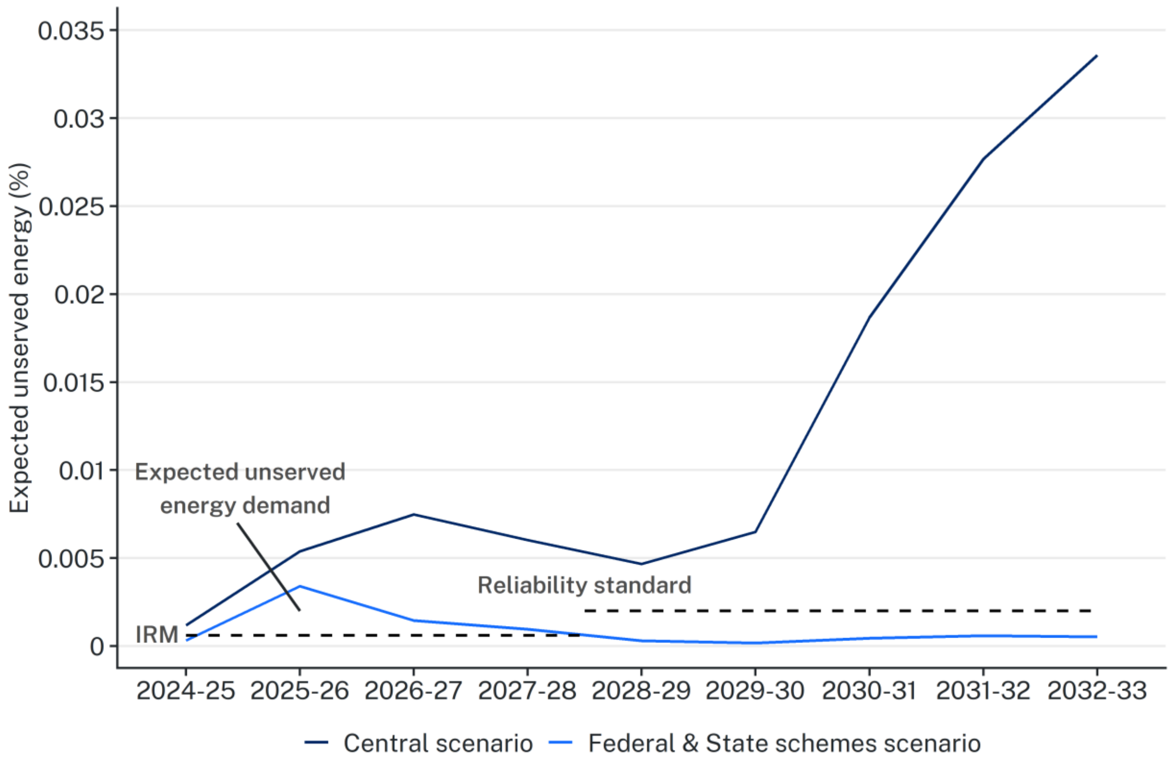
The construction sector's limited capacity contributes to these delays. The sector is being stretched by many large public infrastructure projects. In coming years, the national push to accelerate housing supply will worsen this capacity crunch.

In the additional 'federal and state schemes' scenario — which includes additional investments in generation, dispatchable capacity, and transmission — the 2023 ESOO update saw an improvement from the 'central' scenario (Figure 15). Adding in these projects shrunk the gap between expected unserved energy and the interim reliability measure (IRM). But though reduced, a reliability gap still existed in 2025-26, 2026-27, and 2027-28.

[16] The Waratah Super Battery is expected to begin operating in 2025.

Figure 15: Prospects for an IRM breach fall with NSW and Commonwealth measures

Expected unserved energy in NSW



Source: (AEMO, 2024d).

Extending Eraring's life

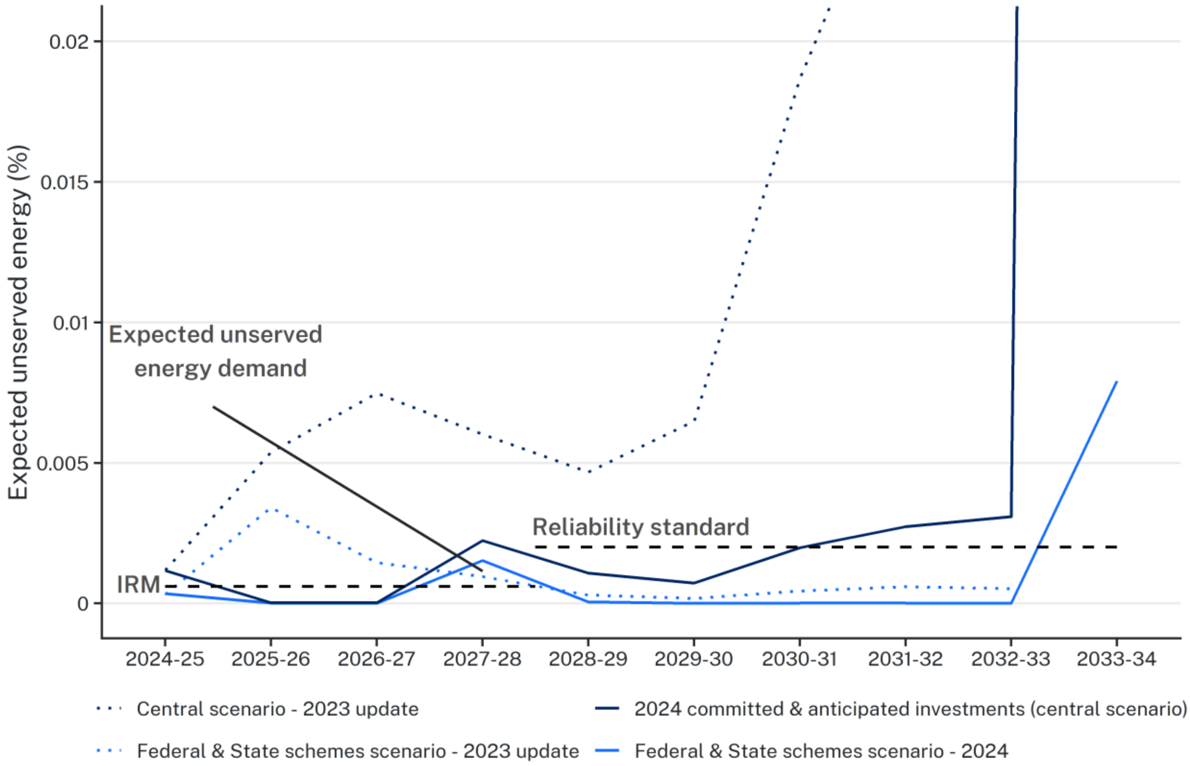
In May 2024, the NSW Government responded to this forecast IRM breach by offering to underwrite Origin Energy to operate its Eraring facility for two additional years beyond August 2025. The decision to support Origin was informed by AEMO's Energy Security Target Monitor (ESTM) 2023 update (AEMO, 2023), which forecast a breach of the EST were Eraring to close in 2025 (see Appendix C).

Origin's option with the State allows it to opt in for both, one, or none of the years covered by the May 2024 agreement. If Origin opts in, Eraring will be obligated to produce six terawatt-hours of electricity a year, about a third of the 16 terawatt-hours that the facility produced in 2023. The State would compensate Origin for up to 80 per cent of any losses, to a maximum to $225 million a year, that Eraring may incur producing those six terawatt-hours. Conversely, the State would be allowed to share a portion of any profit up to $40 million in either year.

Origin's option to extend Eraring with the underwrite will resolve reliability gaps for the near term. The 2024 ESOO found that Eraring's extension and additional generation projects moving to 'committed' has lowered the risk of an IRM breach in the near term. However, in 2027-28, when Eraring is now expected to close, there is still a breach of the IRM because of delays in several key projects.

Figure 16: Eraring's extension and new projects delay IRM breaches

Expected unserved energy in New South Wales

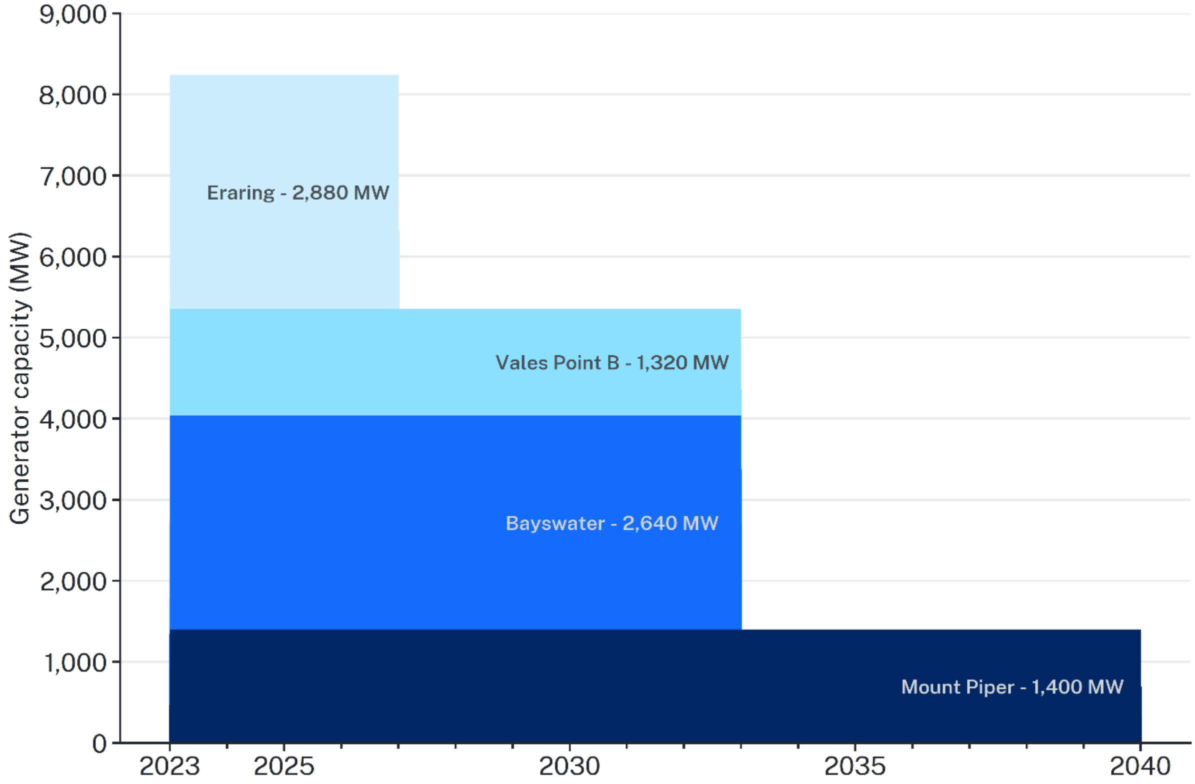


Source: (AEMO, 2024d), (AEMO, 2024g).

The Origin transaction is based on conservative scenarios that are, in turn, built on conservative modelling of reliability and security risks. These conservative models reflect a high social value placed on reliable electricity supply. Figure 17 shows the new timeline of planned closures to the state's coal-fired electricity generators.

Figure 17: The revised outlook for thermal coal generator closures

Coal generator capacity and scheduled closure dates



Note: The 2027 closure date for Eraring assumes Origin will opt into the Government underwrite for both years but will not elect to operate until 2029.
Source: (AEMO, 2024e).

Possible unintended consequences from the Eraring extension

While it may have addressed immediate reliability risks, the Origin transaction does, however, carry the risk of unintended consequences. An additional 12 terawatt-hours of electricity generated over two years should put significant downward pressure on wholesale prices in the NSW region of the NEM. This could threaten the viability of other coal generators for three reasons:

- The parent company of Vales Point Power Station, Sev.en, purchased Vales Point owner, Delta Energy, based on the August 2025 Eraring closure schedule. At the time, Sev.en signalled it was willing to invest in the power station to comply with looming pollution standards and extend its operations to 2033. (Vales Point Power Station is also located on the Central Coast, not far from Eraring.) The prospect of a publicly underwritten extension of Eraring's operation poses downside risks to Vales Point's profitability. This could see its owner reconsider, and potentially bring forward, Vales Point's closure.
- The Mount Piper Power Station's main sources of coal supply is increasingly insecure, posing risks to its continued operation. These risks would be accentuated by lower wholesale prices arising from Eraring's extended operation. This could prompt owner Energy Australia to wind up Mount Piper's operations much earlier than the currently planned 2040 closure date.
- Unanticipated interventions such as the Origin transaction can pose risks to new investment. The private sector might hesitate to invest if its assets could be

unexpectedly stranded by agreements to extend the operation of otherwise unviable generators.

In summary: interventions such as the Eraring extension may create new problems. Added to this risk and uncertainty are the costs of complying with multiple state and Commonwealth policies, particularly for maintaining very high system reliability. Policymakers need to be cognisant of these additional risks and uncertainties as the electricity transition progresses through a relatively tight timeframe.

4.3 Managing demand and containing costs in the electricity transition

As discussed, coal generators are increasingly costly, inflexible, and unreliable. But it is also clear the speed of the exit of coal-fired generation from the electricity system cannot be projected with high accuracy.

AEMO's 2024 *Integrated System Plan* depicts the scale of the investment task across the NEM, justifying the diversity of stakeholder views and its use of scenario planning. The challenges for the system's transition include:

- **New capacity** – producing a ninefold increase in utility-scale renewables, a fivefold increase in distributed solar, a tripling of firming capacity, and 10,000 kilometres of transmission lines.
- **Demand-side participation** – providing two-way electricity flow and digital innovations to support cost-reflective pricing, demand response, and smart 'behind-the-meter' virtual power plants.

The need to efficiently sequence economy-wide decarbonisation further complicates the transition in electricity. The NEM needs to transition to near-zero emissions while maintaining high reliability. At the same time, other sectors — buildings, manufacturing, mining, and transport — must shift to electricity to reduce their own reliance on fossil fuels. But if we electrify other sectors while coal still dominates electricity generation, we could unduly prolong the lives of coal power stations. This, in turn, could jeopardise our ability to meet near-term emissions reduction targets.

The problem of emissions reduction in electricity generation therefore cannot be divorced from broader considerations:

- meeting state and national reliability standards (such as the NSW Energy Security Target and the National Electricity Market's interim reliability measure)
- minimising costs to consumers
- prioritising electricity decarbonisation *before* other emitting sectors substantially electrify and decarbonise
- ensuring emissions fall fast enough to meet our interim legislated targets
- providing policymakers with flexibility to ramp up climate change mitigation efforts, including Australia's 2035 Nationally Determined Contribution.

Above all, this requires a strategic approach to policy that avoids undue risk and uncertainty to private investment.

State and Commonwealth policies supporting the net zero electricity transition are discussed in detail in Appendix B. But additional actions are needed. The next section discusses potential actions.

Further reforms to minimise transition costs in the electricity sector

In August 2023, the Australian Energy Market Commission (AEMC) released its final report, *Review of the Regulatory Framework for Metering Services* (AEMC, 2023). It found significant net economic gains are possible from speeding up digital 'smart' meter installation in New South Wales and the ACT, with the aim to give all users smart meters by 2030. This followed the NSW Productivity Commission's May 2021 recommendation to evaluate a quicker rollout of smart meters in the state, coupled with mandatory cost-reflective retail pricing.

Mandating cost-reflective retail electricity tariffs

Most NSW retail electricity customers pay a flat rate tariff for their electricity regardless of when it is used, comprising:

- a daily fixed charge
- a flat electricity usage charge per kWh.

This pricing approach has traditionally been used because analogue meters could only tell *how much* electricity a customer used, not *when* it was used.

Smart meters offer opportunities to move beyond this model. These devices measure when customers use electricity and how much. Energy use is recorded in 30-minute intervals and this information is transmitted directly to retailers. Smart meters are complemented by other digital innovations — online platforms and applications — that signal near-term prices to consumers. Smart household appliances are also an emerging technology.

Depending on the extent of consumer behavioural change, households and businesses could achieve significant bill savings from digital technologies. For example, customers with smart meters can enjoy reduced 'solar soaker' tariffs offered by distributed network service providers (DNSPs) when variable renewable energy is abundant.

Despite the rollout of smart meters, many customers still opt for flat-rate tariffs. This is perhaps because it gives them more certainty over their bill or because they have an aversion to change. But flat rate tariffs are not reflective of the system costs of electricity at specific times. They don't provide consumers with the incentive to smooth energy demand over time. The electricity system — generation, storage, and transmission and distribution infrastructure — must therefore be built to ensure high reliability during periods of mostly unmitigated peak demand.

Mandatory, cost-reflective electricity tariffs would allow comprehensive management of demand by all users. It would have the following benefits:

- consumers would receive the power they need in peak periods while deferring non-essential usage into the off-peak period in exchange for bill savings
- containing system demand in peak periods would reduce stress on current assets, maximising reliability, minimising maintenance costs, and moderating new capital expenditure
- system-wide cost savings would minimise pressure on customer bills, limiting pressure for *ad hoc* interventions in the market that risk unintended consequences and additional costs.

The NSW Government should investigate retailer regulation to support transitioning all electricity customers onto mandatory cost-reflective tariffs. Box 5 shows there are a variety of pricing options. (It may be more appropriate to set minimum requirements rather than mandating specific tariffs.)

Box 5: More cost-reflective residential tariffs

There are options available for electricity retailers to charge customers for electricity in a more cost-reflective way. Examples include:

- **Time-of-use tariffs**: the retailer sets higher usage charges for peak evening and seasonal periods and lower charges during off-peak periods. Many customers in Australia already have time-of-use tariffs, with some retailers offering it as a default for smart meter customers.
- **Critical peak pricing**: the retailer charges a higher usage charge on days with very high demand, typically 10-15 days a year. Often this is communicated to customers a day in advance via text message.
- **Demand tariffs**: include a third charge to the bill based on the highest amount of power used during peak periods. Demand tariffs are already used for large commercial customers and are available for residential customers from some retailers.
- **Real time tariffs**: the retailer passes through the cost of wholesale electricity directly. Around half of electricity customers in Spain currently current receive electricity using a real time tariff (Red Eléctrica, 2024).

Smart meters are already required in all residential and business developments and when existing metering systems are replaced. But as of April 2024 DCCEEW estimates New South Wales to have the lowest smart meter penetration of NEM-participating states, at 44.3 per cent. This is slightly behind Queensland and South Australia — at 45.2 and 47.9 per cent respectively — and well behind Victoria, with greater than 99 per cent.

An effective demand management approach will improve system efficiency only when several challenges are overcome. Among them is the need for a critical mass of smart meters providing detailed data on the retail market. This will provide retail businesses with the information they need to pass through bill savings when customers change their usage to low-cost periods. This will ensure the benefits of lower costs flow to consumers. But regulatory intervention is needed to expedite the rollout. Moreover, regulation that mandates cost-reflective pricing is essential to maximising savings in system costs digital technologies and demand management offer.

As the NSW Productivity Commission's 2021 White Paper flagged, v*oluntary* cost-reflective pricing limits the demand management benefits of peak pricing, and so contributes little to containing system costs. Inefficiencies arise from such a system as follows:

- lower off-peak tariffs benefit users with relatively high off-peak use, so these customers would choose the cost-reflective offer
- but if standard offers continue, they would be chosen by customers with high peak use who are unwilling and/or unable to shift much demand into the off-peak period
- the system would therefore continue to be built for largely unmitigated peak demand, with no significant containment of overall system costs.

Implementing virtual power plants

The potential of consumer energy resources to moderate costs should not be understated. More recent modelling by AEMC (2024a) estimated cost savings of up to $2 billion (net present value). Box 6 illustrates how virtual power plants (VPPs) can enhance the two-sided electricity market now emerging to reward customers while containing utility-scale generation and network investment. AEMO (2024b) estimates that without effective coordination of consumer batteries, the grid will need $4.1 billion of additional investment. That extra cost would ultimately be borne by energy consumers.

In July 2024 the AEMC made a draft determination (2024b) on price-responsive resources for the NEM. The draft determination proposes three changes:

1. allowing aggregated consumer energy resources, including VPPs and community batteries, to be scheduled and dispatchable
2. creating a short-term incentive payment to drive participation in dispatch
3. introducing monitoring and reporting functions to better understand the forecasting challenges and errors from unscheduled price-responsive resources.

Box 6: The potential of VPPs

As the electricity sector decarbonises and becomes more reliant on variable renewable energy, harnessing the capacity of behind-the-meter energy assets will play an important part in maintaining grid reliability.

A VPP connects disparate behind-the-meter assets — home batteries, electric vehicles, and solar panels — and allows them to be centrally controlled, effectively functioning as a standalone power plant. A VPP can be activated very quickly to address frequency and voltage imbalances and local disruptions or disturbances. This helps to keep the electricity grid stable. A VPP can also be deployed in a standard manner to provide cheap, renewable energy to the grid.

One of the successful projects in the NSW Firming Tender Round 2 was a combined three VPPs with total capacity of 95 MW and minimum duration of two hours. This project is currently slated to be Australia's largest of its kind when it begins operating in 2025-26. The three VPPs will help New South Wales manage the exit of its ageing coal-fired power plants.

Allowing the full integration of these technologies — including through the Roadmap and CIS — will support a more efficient, reliable, and secure system, containing costs as the NEM decarbonises.

These reforms would be in addition to those established by the NSW Consumer Energy Strategy, with similar benefits. The Strategy is a suite of policies to support households and small businesses to reduce their energy consumption and invest in consumer energy resources. Programs and incentives established under the Strategy include:

- helping apartment residents invest in solar systems
- energy saver and appliance energy performance initiatives
- home battery incentives.

Construction sector capacity and the electricity transition

Construction sector constraints will have a large effect on the speed of electricity decarbonisation. The May 2024 ESOO (AEMO, 2024g) update shows the possible risks to timely delivery of replacement generation and transmission capacity. The market operator now registers delays to already committed generation and network projects, including the following:

- **EnergyConnect** – a transmission link with South Australia. Stage 1 has been delayed by four months, and Stage 2 by 12 months.
- The **Central-West Orana transmission** link to the pilot renewable energy zone has been delayed by 11 months from September 2027 to August 2028.
- The **Orana** and **New England Solar Farm Battery Energy Storage Systems** has been delayed by 13 months, and 30 months respectively.
- The **Riverina solar farm** and **Sapphire wind farm**, both delayed by 18 months.

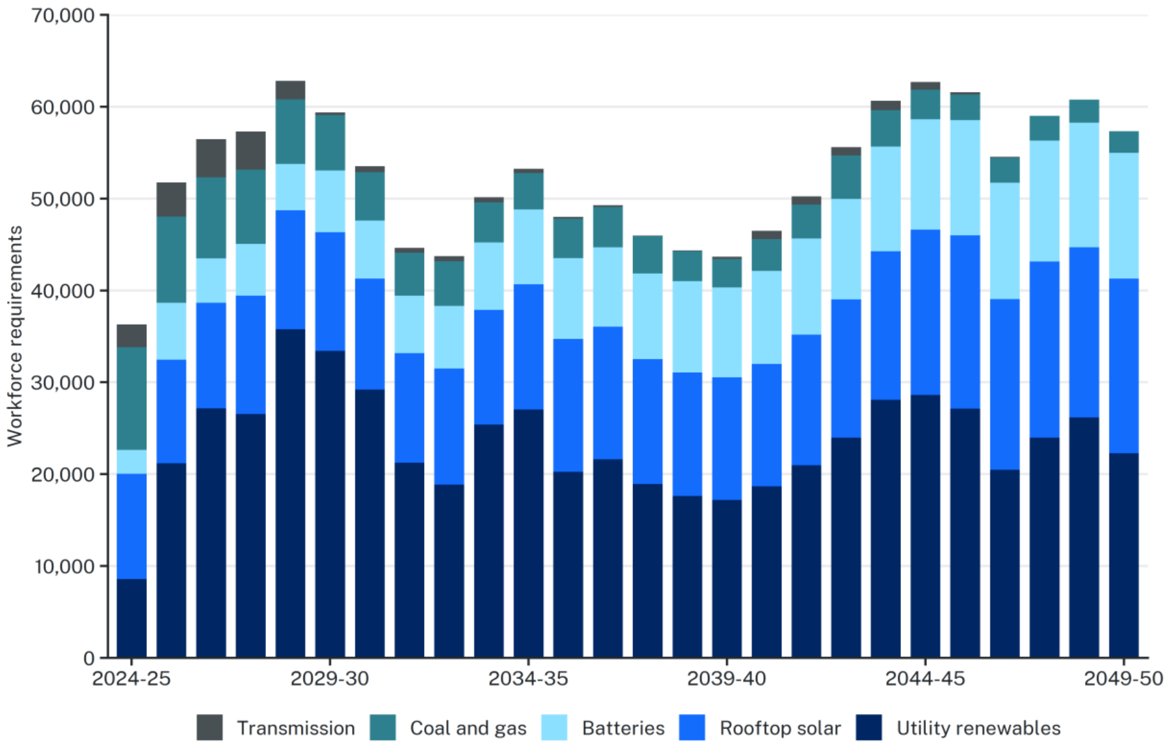
AEMO has already seen the cost of new transmission capacity rise by 30 per cent since 2022. This is attributed to global competition for materials and capital and to domestic labour supply constraints.

Scarcity of construction sector resources has second-round impacts that can adversely impact the cost of living. The electricity transition is an investment task that must be paid for. The more public infrastructure expenditure competes with the private sector for limited capacity, the higher the costs that must be recovered from households and businesses.

The 2024 *Integrated System Plan* (ISP) estimates more than 60,000 skilled workers will be needed to build and maintain an increasingly low emissions NEM (Figure 18). This represents an increase of up to 30 per cent in projected labour demand in most years compared to AEMO's 2022 estimates. As the most populous state, New South Wales will employ a significant proportion of these workers, if they can be induced here.

Figure 18: The net zero transition will require additional highly skilled workers

Workforce needs for delivery of utility-scale capacity and consumer energy resources, NEM (2024-25 to 2049-50)



Source: (AEMO, 2024b).

Stakeholder feedback on the ISP called for a 'delivery risk' scenario that included supply chain constraints and shortages of skilled labour. Stakeholders also asked AEMO to publish detailed electricity sector workforce projections sooner. This reflected concerns that labour might not be available to deliver energy projects in a timely and cost-effective manner. To support the electricity transition, New South Wales needs to take action to secure a reliable supply of construction-sector workers, across all qualifications and skills levels.

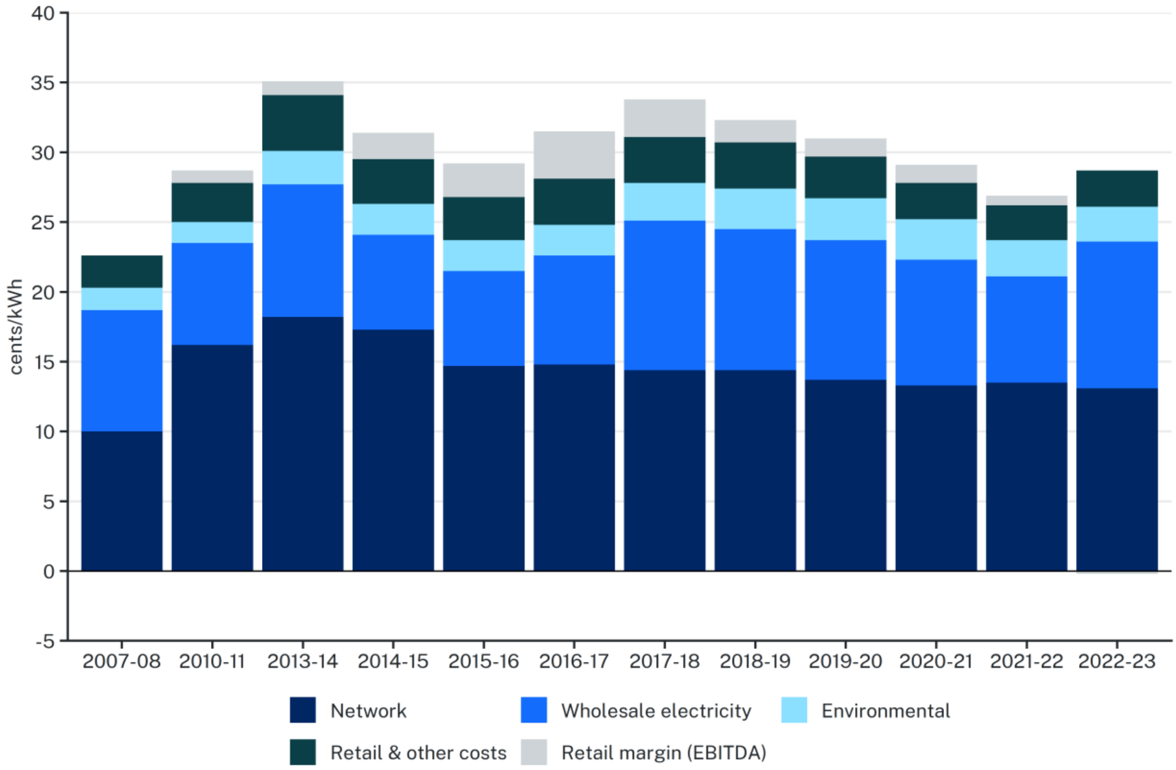
Supply chain constraints and capital availability also limit the speed of electricity's net zero transition. New South Wales is competing domestically and internationally for solar panels, wind turbines, batteries, high-voltage transmission lines, synchronous condensers, and transformers. The ISP estimates, in a supply chain-constrained scenario, the total renewable energy share could be as low as 68 per cent by 2030. This would be well less than the Commonwealth's 82 per cent target. Access to these inputs over the next decade will help determine whether the State's interim legislated emissions reduction targets can be met.

Improving equity by containing costs in the electricity transition

Focusing too heavily on supply-side solutions to maintain reliability during the electricity transition could incur system costs higher than is necessary to keep the lights on. Ultimately, the burden of cost recovery in the electricity system falls on consumers. Network costs (transmission lines, substations, and poles and wires) and wholesale costs (generation, peaking, and storage capacity) overwhelmingly determine the size of customer bills. Of the two components, network costs are the largest, comprising 46 per cent of the average NSW electricity customer bill in 2022-23 (Figure 19). Economically disadvantaged and socially marginalised consumers will be impacted the most by over-investment in network infrastructure.

Figure 19: Network costs are almost half of the average NSW electricity bill

Components of average NSW electricity bill, cents/kWh 2022-23



Source: (ACCC, 2023).

The alternative, cost-effective approach is to efficiently balance investment in the supply side with management of the demand side of the electricity market. It has been shown that disadvantaged groups use as little energy as possible even if it impacts their wellbeing (PIAC, 2024). Conversely, accelerating energy efficiency improvements, maximising the potential of digital technologies, and mandatory cost-reflective pricing can disproportionately benefit them. By efficiently transitioning both sides of the market, the journey to net zero can maximise the welfare of consumers and minimise impacts on lower-income groups.

The role for gas in a net zero electricity system

To maintain reliability, variable renewable energy must be balanced — or 'firmed' — with dispatchable electricity. Based on the successful 2023 Commonwealth-NSW 1,075 MW firming tender, much of the capacity needed is likely to be provided by grid-scale batteries and demand response. Batteries are enjoying declining generalised costs. Pumped hydro projects, however, are riskier, given their large capital costs and long planning and delivery times. Delays and cost overruns in the delivery of the Snowy 2.0 project are illustrative: originally announced with a 2022 delivery date, it is now scheduled to come online in 2028.

AEMO's 2024 *Integrated System Plan* (2024b) affirms that the lowest cost electricity through the energy transition will come from renewables firmed with a combination of storage and peaking generation. There may, therefore, remain a role for gas for firming capacity for a long time to come, especially if long-duration storage delivery times continue to disappoint.

Renewables and batteries can still achieve a very high share of generation capacity — close to 100 per cent in some scenarios — even when combined with gas peaking generation. But attempting a 100 per cent renewables system may prove prohibitively expensive (Wood & Ha, 2021). A net zero electricity system could require gas generation as a firming technology for the foreseeable future, with its emissions offset by Australian Carbon Credit Units.

AEMO's 2024 *Integrated System Plan* estimates having sufficient gas generation capacity to back up renewable energy will require $230 million for fuel and fuel storage. (The gas stored might be a combination of natural gas and renewable fuels such as 'green' hydrogen.)

The *2024 Gas Statement of Opportunities* (AEMO, 2024f) forecasts seasonal gas supply gaps to emerge from 2026 and annual supply gaps from 2028. Growth in gas-generated electricity demand is expected from the early 2030s, with significant growth in peak consumption, as is declining gas supply. This is expected to more than offset declining gas demand from residential, commercial, and industrial consumers.

A combination of solutions will be required to mitigate shortfalls. This could include acceleration of efforts to electrify residential, commercial, and industrial premises. State levers available to quicken this transition will be discussed further in later volumes of the *Achieving net zero* series.

Appendix A: Marginal abatement costs, carbon values, and policy evaluation

The *marginal abatement cost* (MAC) of a decarbonisation solution is equal to the net present value of the solution's cost (including both capital and operation expenditures) divided by the emissions reduction achieved over the solution's lifetime. This calculation produces the marginal cost of abatement per tonne of emissions. The carbon value for a particular year is then derived from the maximum marginal abatement cost for that year. This is the cost associated with the last (and most expensive) solution required to meet that year's emissions reduction target.

Importantly, these carbon values are consistent with the cost to meet our net zero targets; they do not price the cost of damage to the environment caused by greenhouse gas emissions. As a result, carbon values should not be used to determine the costs of emissions or any level of government subsidy or tax. Carbon values are highly sensitive to changes in baseline emissions projections and so only the most up-to-date carbon values should be used.

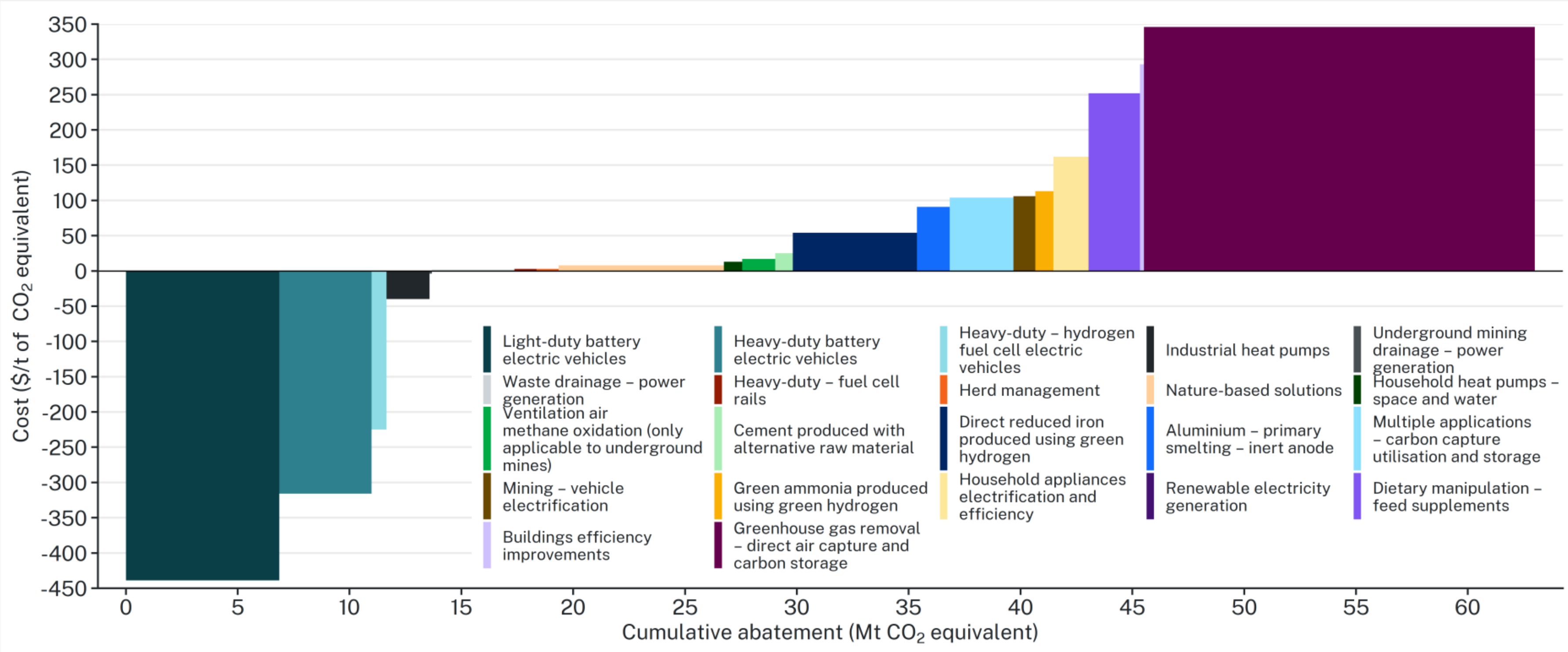
Box 7 provides an example of this approach using the 2050 net zero target.

Box 7: Closing the 2050 net zero gap using carbon values

Using the most recent baseline emissions projections for New South Wales, the gap to net zero in 2050 will be 60 Mt. Based on the 2050 MAC curve, the carbon value is around $350/tonne. This is the marginal cost of direct air carbon capture and storage, an inefficient and expensive abatement method. In total, it would cost $2.4 billion to abate the final 60 Mt of emissions fully utilising all available abatement solutions.

Figure 20: Marginal abatement cost curves allow us to estimate the cost of emissions reduction

Marginal abatement cost curve, 2050



Note: This MAC curve is for illustrative purposes only; marginal abatement costs and abatement volumes are liable to change.
Source: (DCCEEW, 2024b).

Appendix B: Commonwealth and State policy to support the electricity transition

In August 2022, the Commonwealth, state, and territory energy ministers agreed to include emissions reduction in the **National Electricity Objective**, National Energy Retail Objective, and National Gas Objective within the national energy legislative framework. This requires AEMO, the Australian Energy Regulator and AEMC to consider the achievement of Commonwealth, state, and territory emissions reduction targets alongside existing objectives, including reliability, security, price, quality, and safety, in relevant decision-making processes.

In November 2023, Australia's energy ministers agreed to expand the **Capacity Investment Scheme** (CIS) to support delivery of 9 GW of zero-emissions dispatchable capacity and 23 GW of utility-scale variable renewable energy. This built upon the first pilot competitive auction delivered in collaboration with New South Wales in 2023 to procure 1,075MW of new firming capacity. Successful projects include a 415MW/1,660MWh four-hour battery in Orana and the 500MW/ 1,000MWh two-hour battery at Liddell.

The CIS acts as a guarantee on returns. If energy prices fall below an agreed 'floor', energy companies will be subsidised for this shortfall. Equally, if prices rise above an agreed ceiling, these supernormal profits will be returned to government. This effectively removes risk and gives some certainty to investors. However, the costs and prices floors and ceilings will remain commercial-in-confidence. The scheme will be effective in bringing online renewables in the short term. But it is likely that the costs will not be felt until later in the decade, when more renewables are online, and energy prices are more likely to fall below the agreed floor.

The CIS is modelled on **Long-Term Energy Services Agreements** (LTESAs) awarded through competitive auctions by AEMO Services as the NSW Government's Consumer Trustee.[17] LTESAs give generation investors the option to sell their output at an agreed minimum price to a scheme financial vehicle, which on-sells output to retailers. Any losses incurred by the vehicle are passed on to distribution companies for recovery – ultimately from consumers.

LTESAs are also available for investors in long- and short-duration storage and demand response projects. These LTESAs are made as financial derivative contracts to access annuity payments.

LTESAs are one component of the **NSW Electricity Infrastructure Roadmap**, enacted by the *Electricity Infrastructure Investment Act 2020* (NSW). The Roadmap requires a minimum 12 GW of generation and 2 GW of long-duration storage to be constructed by 2030. It coordinates investment in generation, firming, and transmission infrastructure, timed for delivery when, or before, coal generators close. Other components of the Roadmap:

[17] AEMO Services is a subsidiary of AEMO and was created that way to be independent and transparent in carrying out its functions as the NSW Government's Consumer Trustee. Shareholders in 'AEMO Limited' are AEMO and NSW Government.

1. **Renewable Energy Zones** (REZs) are located in five regions: Central-West Orana (the first 'pilot' REZ), followed by Hunter-Central Coast, New England, Illawarra, and Southwest.
2. **Transmissions rights** will be competed on by new generation projects within or supporting REZs to secure access rights to new transmission.

The **Energy Security Safeguard** complements the CIS and Roadmap as a cost-effective abatement program. It comprises four elements:

1. The **Energy Savings Scheme** provides financial incentives to install energy-efficient equipment and appliances in households and businesses. The estimate for the cost of abatement is very low at $41 per tonne of CO_2-e.
2. The **Peak Demand Reduction Scheme** (PDRS) moderates system demand when it is otherwise at its peak, containing overall costs, and providing incentives for the uptake of small-scale storage.
3. The **Renewable Fuel Scheme** was established to encourage the production of green hydrogen in New South Wales. The Scheme sets a target for green hydrogen production that will gradually increase to eight million gigajoules by 2030. Producers will earn certificates for each gigajoule and can sell them to liable parties to meet their obligations under the *Electricity Supply Act 1995* (NSW). Liable parties are natural gas retailers and large users who do not purchase gas through a retailer.
4. Finally, in November 2023, Australia's energy ministers agreed to develop an opt-in **Orderly Exit Management Framework** for NEM-participating generators. The Framework is scheduled to be enacted in South Australia before the end of 2024.

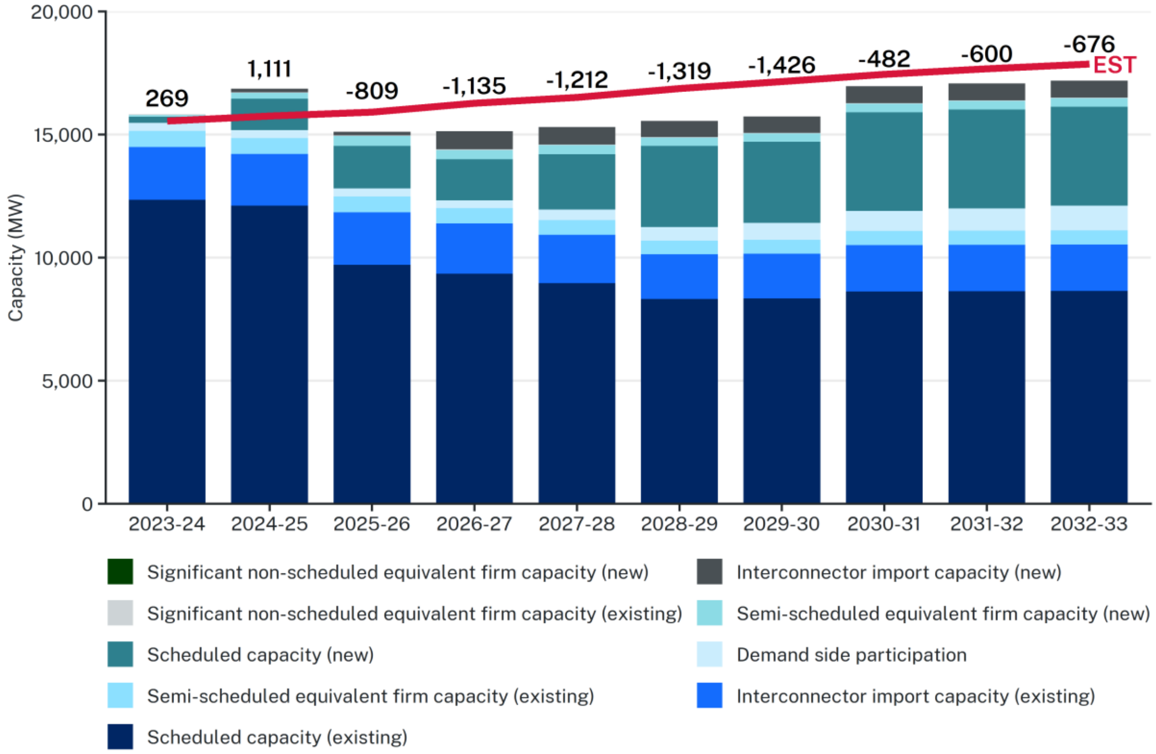
   The Framework provides options to replace the capacity of the thermal generator or temporarily seek an extension to maintain the reliability and security of the energy system. When a generator's planned closure date is brought forward, the relevant minister can seek an assessment of whether an electricity shortfall will emerge and what options are available to close it. Any estimated shortfall will be filled by the lowest-cost solution available. This can include voluntary negotiations to delay the generator's closure.

Appendix C: NSW Energy Security Target & Eraring

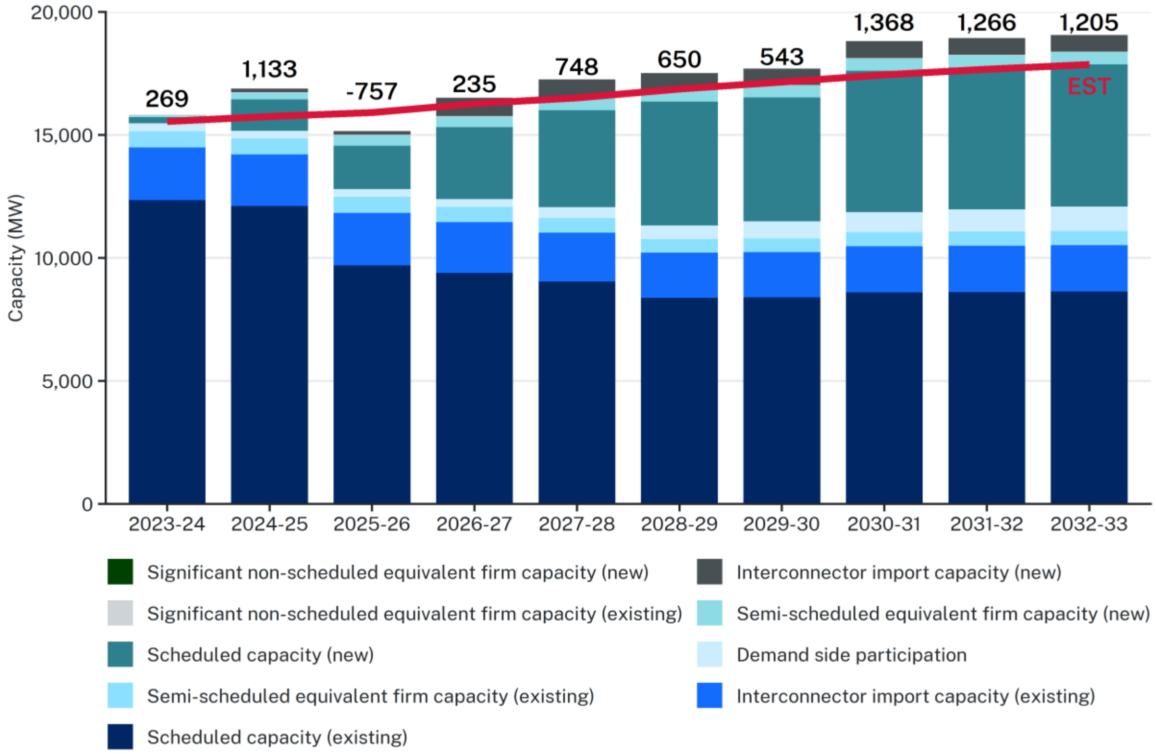
Incorporating an assumption that Eraring would close in August 2025 led AEMO to forecast a breach of the Energy Security Target (EST) from 2025-26 to 2032-33 in the 'central' scenario (Figure 21). The 'infrastructure tenders 2 and 3 with project development delays applied' scenario showed a breach would only occur in 2025-26. (It is important to note that the 757 MW gap in 2025-26 includes delays to projects which are currently proceeding *on or ahead* of schedule, such as the 850 MW Waratah Super Battery.)

Figure 21: Delays to infrastructure commissioning risk an electricity shortfall

ESTM 'central' scenario. Figures above bars indicate extent to which capacity exceeds Energy Security Target or falls short (negative numbers).



ESTM 'infrastructure tender 2 and 3 with project development delays applied' scenario. Figures above bars indicate extent to which capacity exceeds Energy Security Target or falls short (negative numbers).



Source: (AEMO, 2023).

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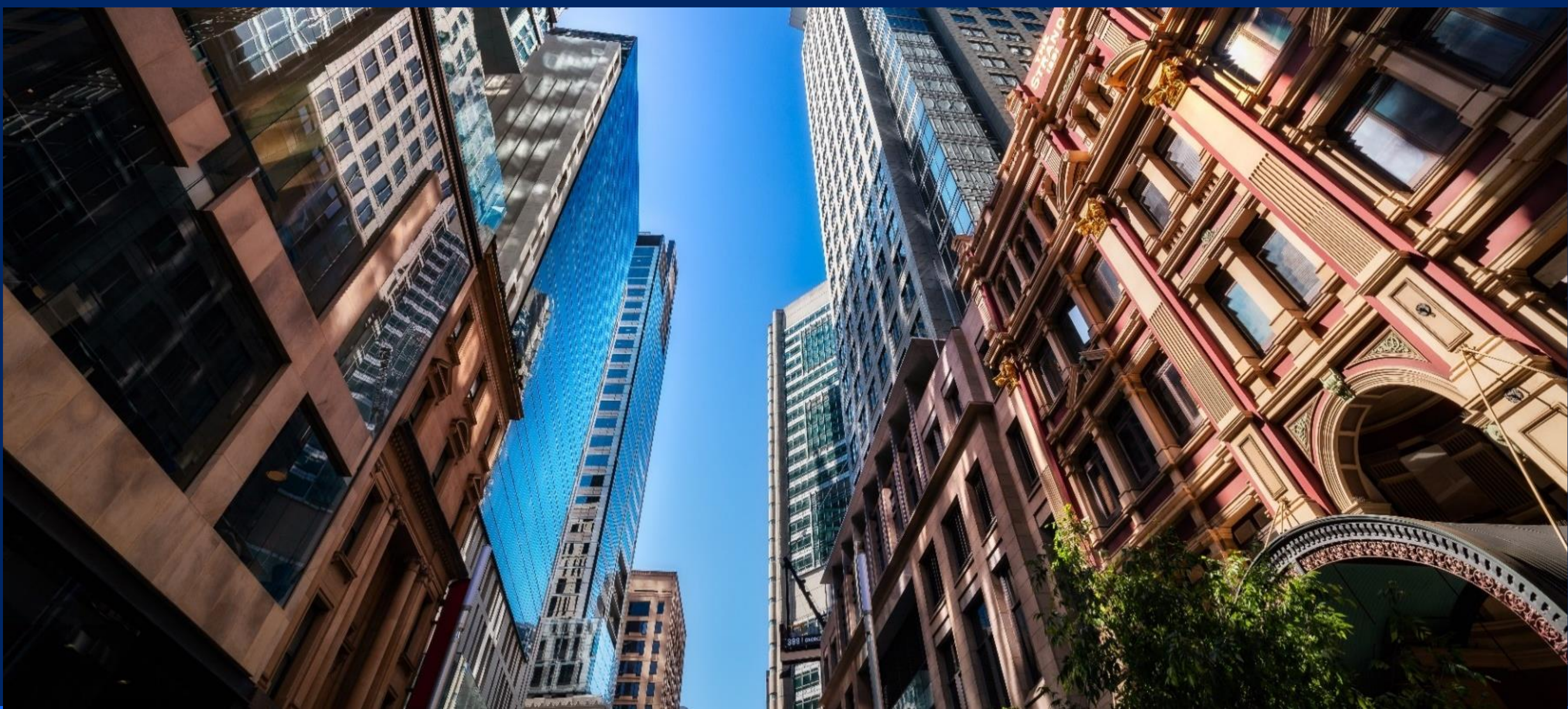
NSW Productivity and Equality Commission

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.

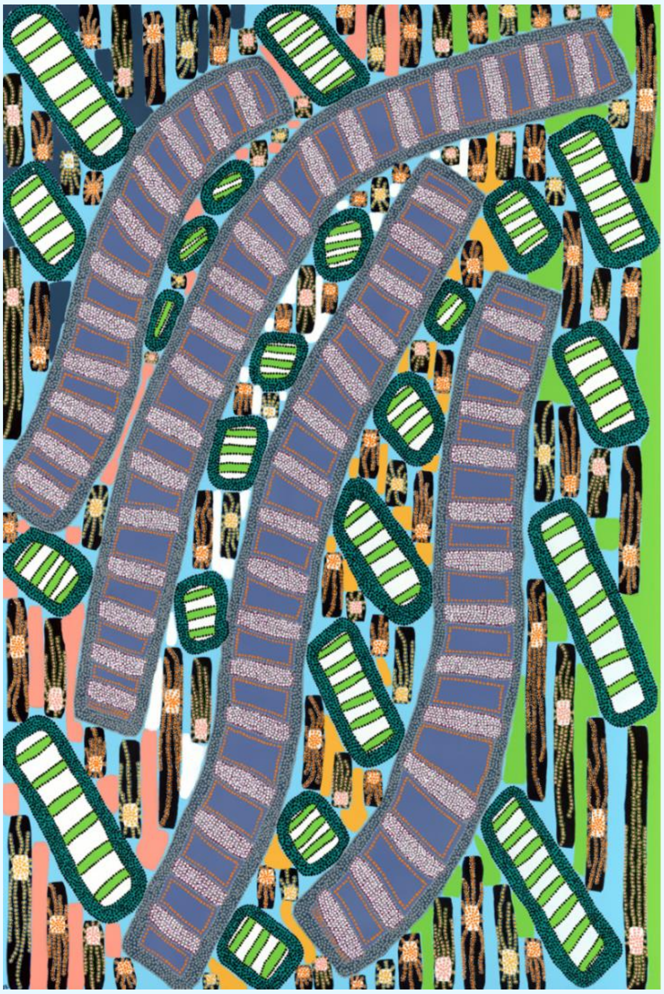
We pay respect to Elders past and present and commit to respecting the lands we walk on, and the communities we walk with.

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

Contents

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.

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[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

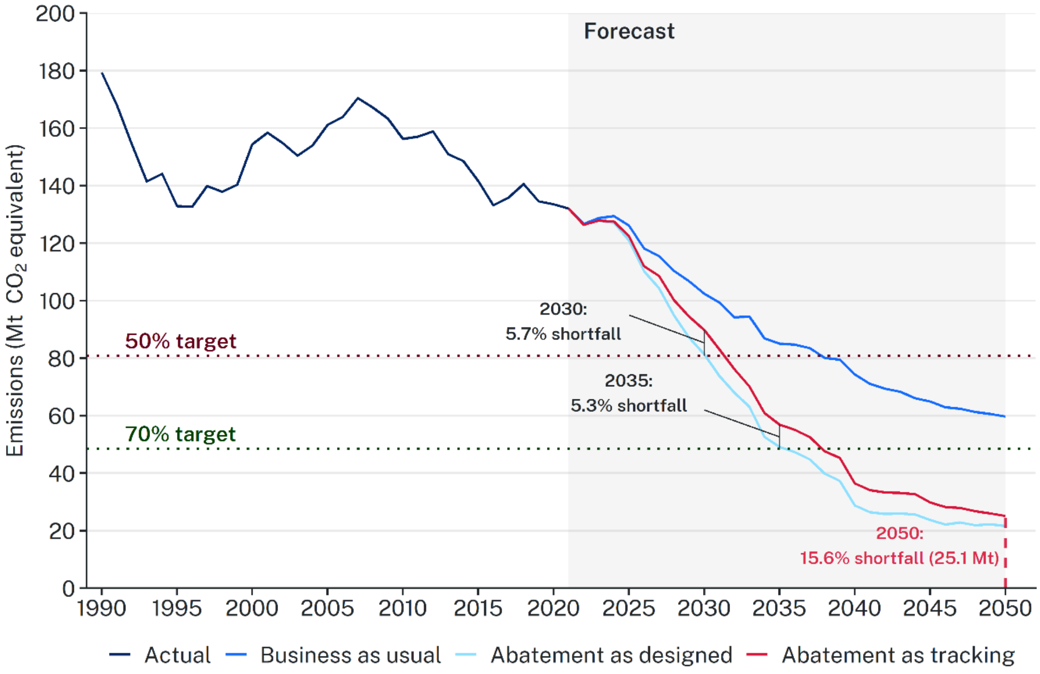
This paper is the second in the *Achieving net zero* series. The first paper focused on the current emissions landscape, emissions reduction targets for New South Wales, and the extent of our progress.

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.

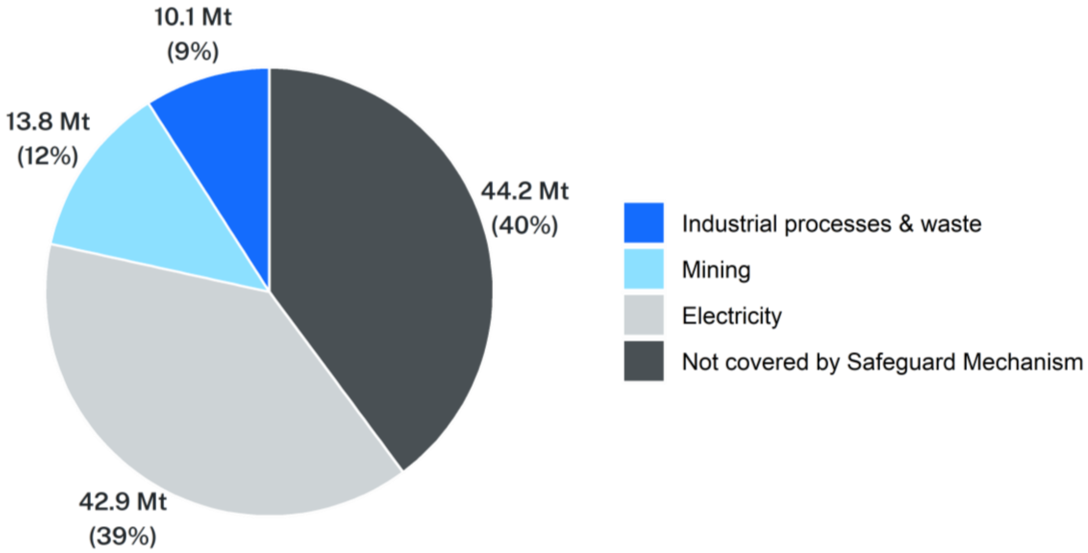
Of the 219 individually regulated Safeguard facilities in Australia, 35 are in New South Wales. These 35 facilities produce roughly 23.9 Mt CO_2-e, or around 20 per cent, of the state's total emissions.

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).

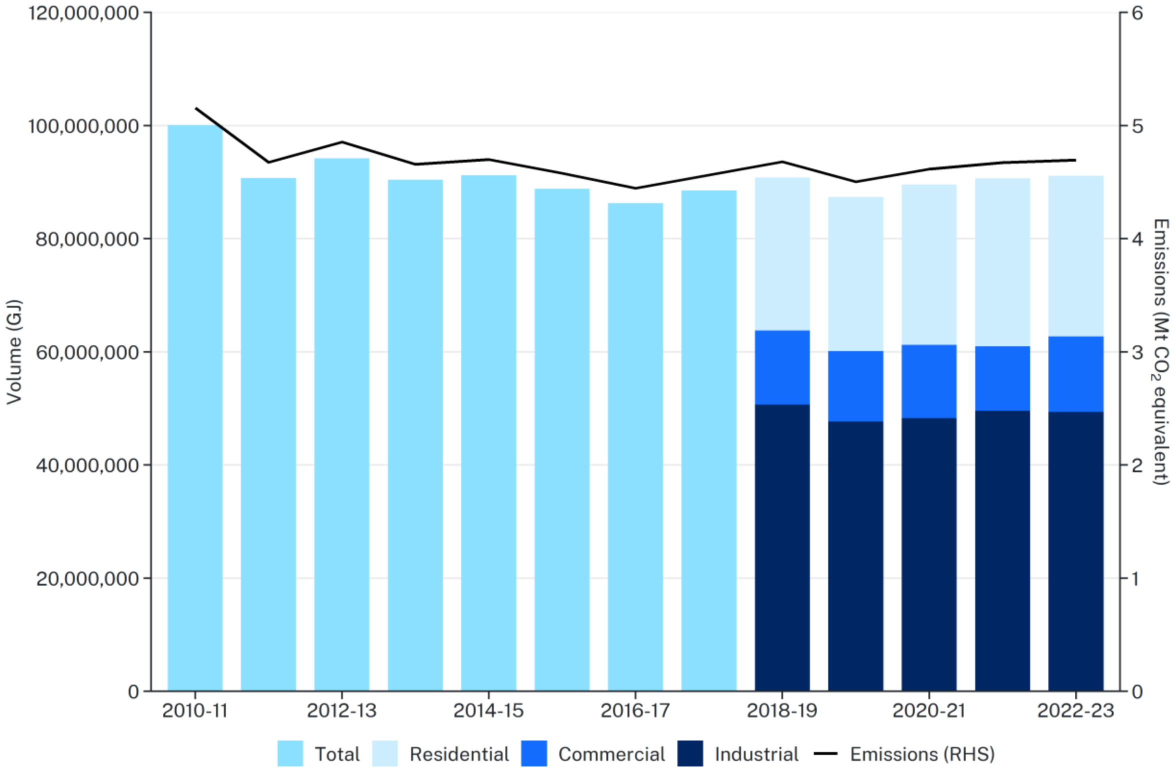
Residential and commercial buildings in New South Wales consumed more than 41.7 million gigajoules (GJ) of natural gas in 2022-23.[4] That was around 46 per cent of total gas consumption.

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



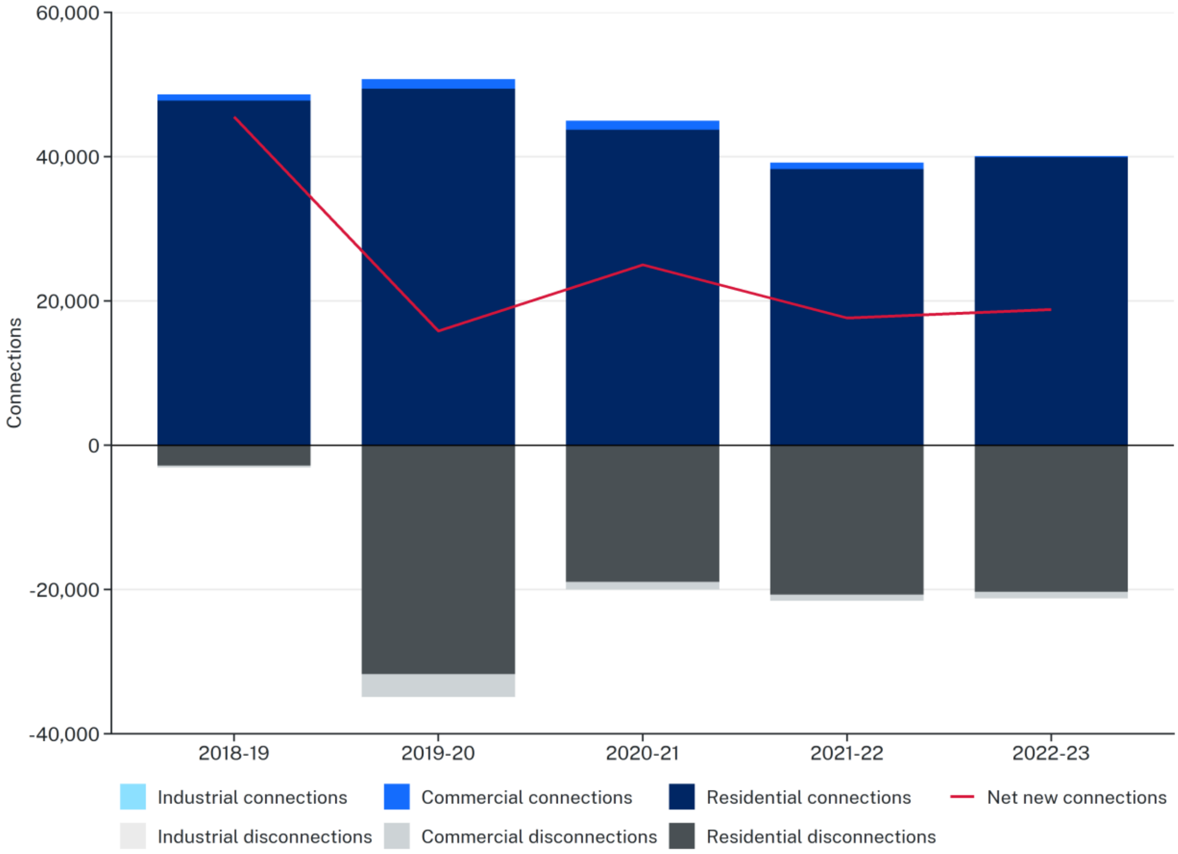
Note: This figure excludes bottled gas consumption.
Source: (AER, 2024a).

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

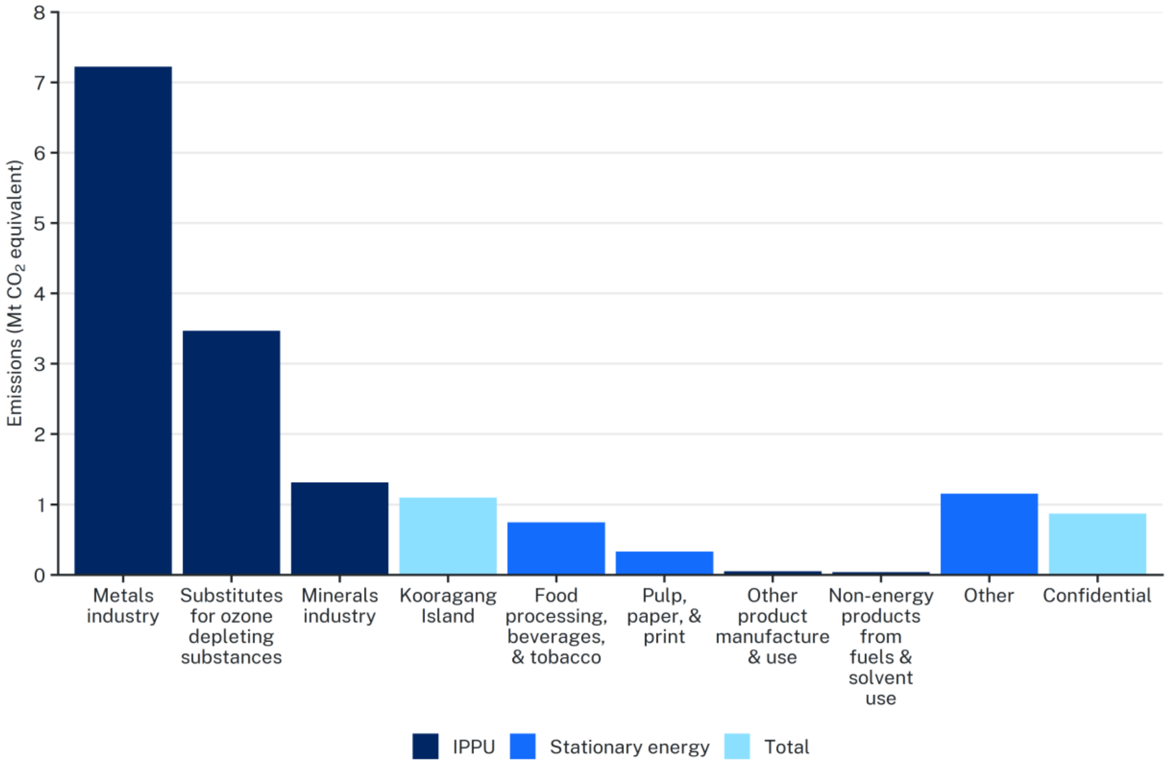
Manufacturing and construction emissions come from two sources — stationary energy and industrial processes and product use.

- **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.

[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.

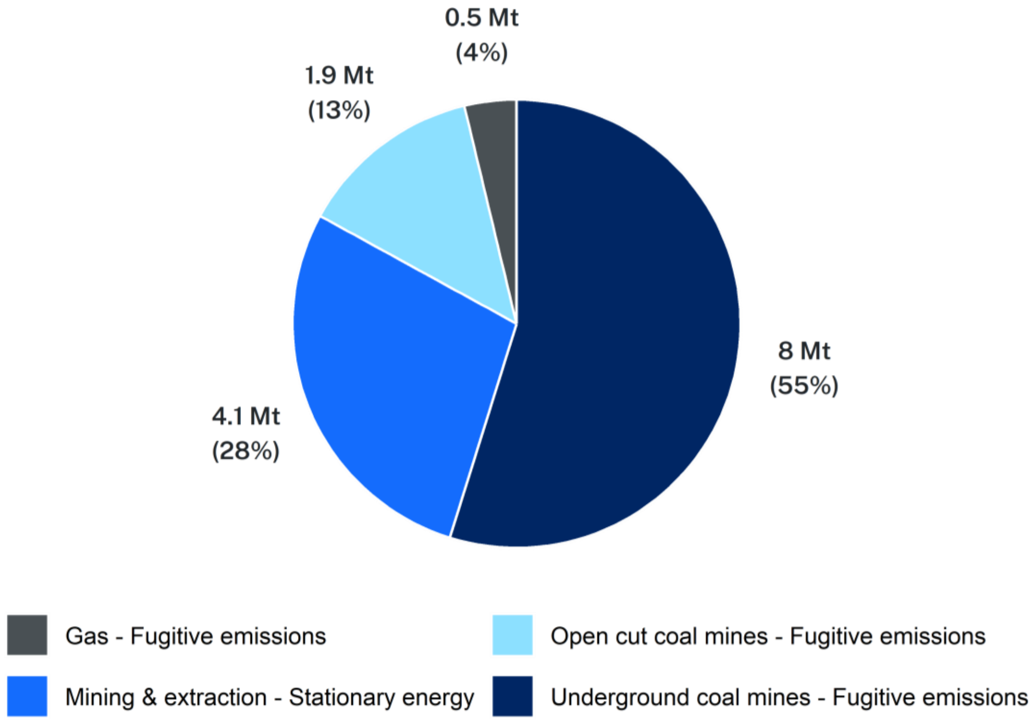
Mining and extraction created 14.5 Mt of CO_2-e in 2021-22, or around 13 per cent of state emissions. These emissions are of two types:

- **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.

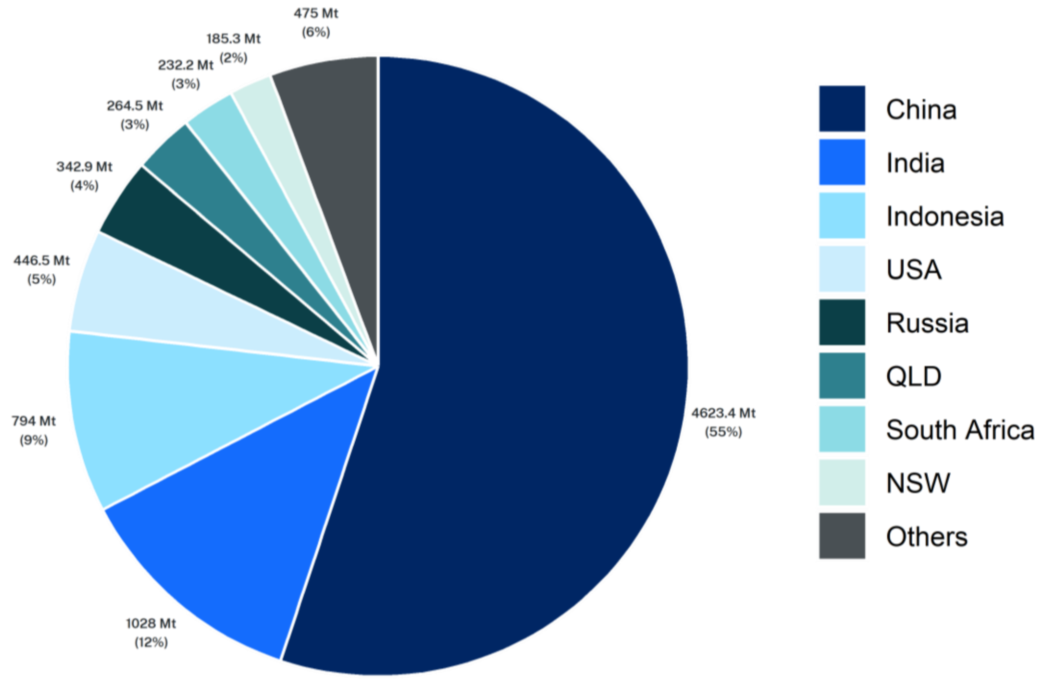
Domestic coal demand for use in electricity generation is projected to be close to zero well before 2050. The AEMO (2024b) 'step change' scenario projects New South Wales to have exited coal-fired electricity generation by 2037. (For comparison, the 'progressive change' scenario projects exit by 2040 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

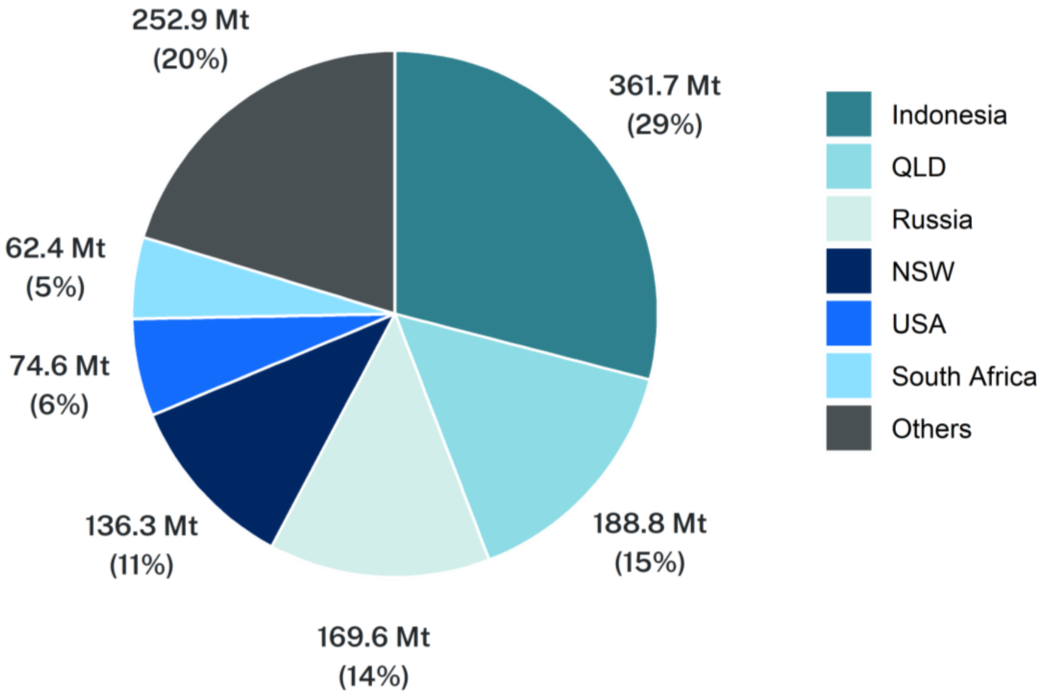
Global coal production by jurisdiction, 2023-24



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

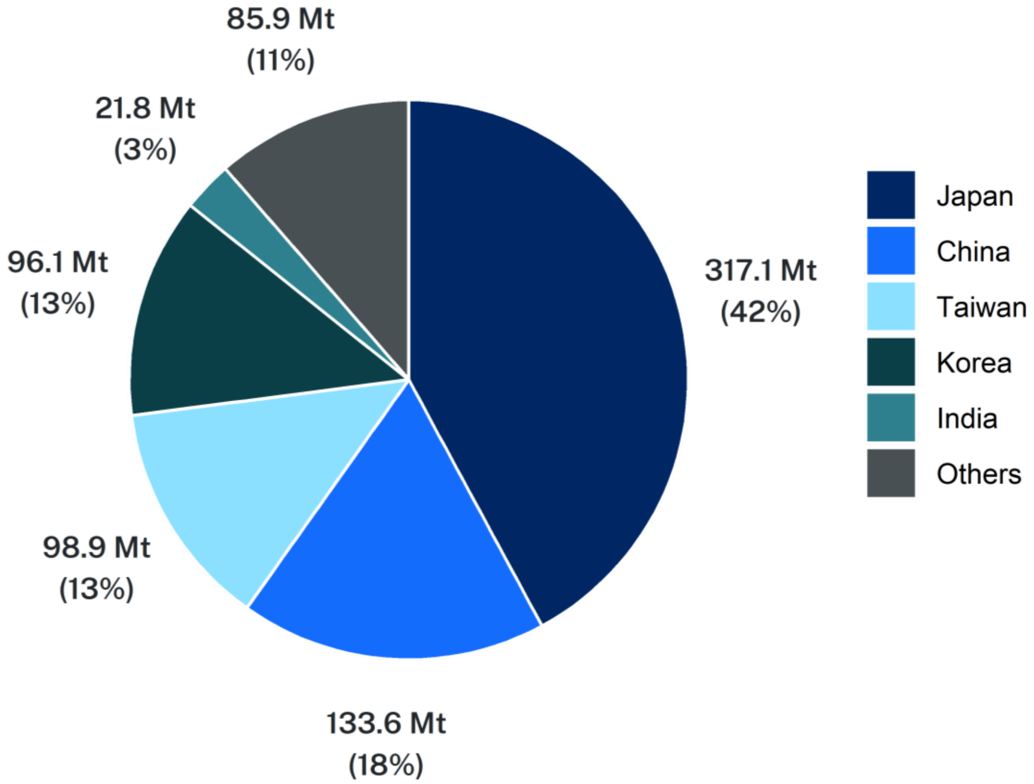


Note: Includes metallurgical and thermal coal.
Source: Department of Infrastructure, Transport, Regional Development, Communications, and the Arts Freight Data Hub 2024, IEA 2024.

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).

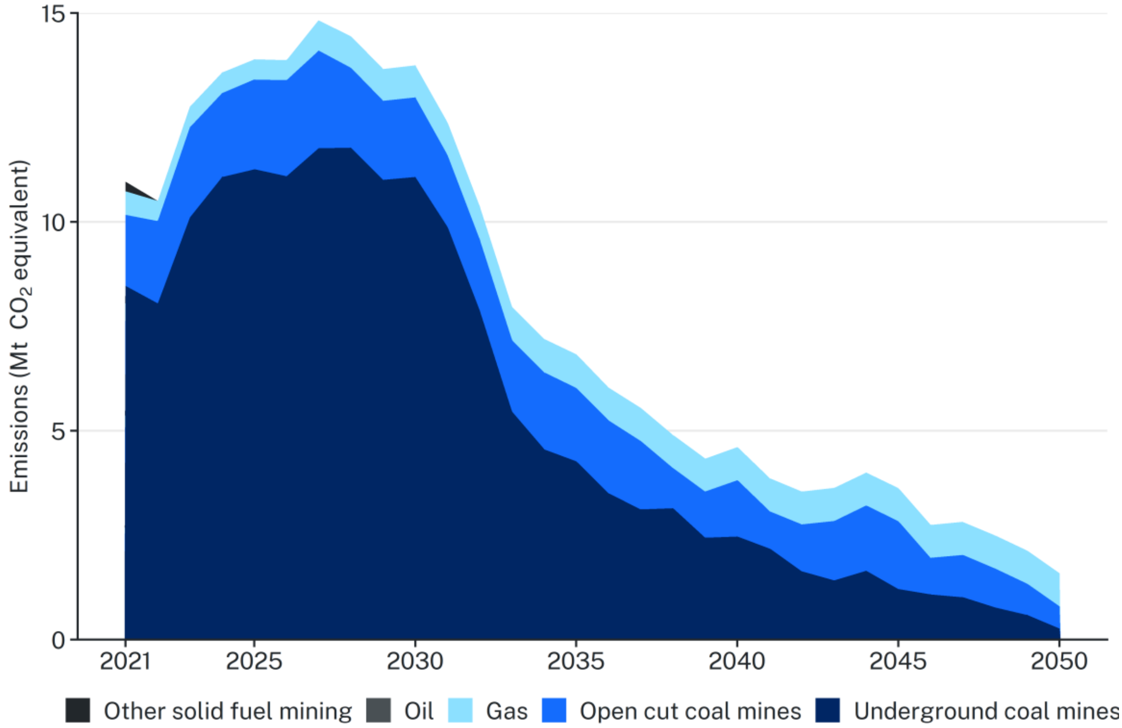
Overall coal demand has recently flatlined or slightly fallen in many of Australia's major export markets (see Box 8).

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).

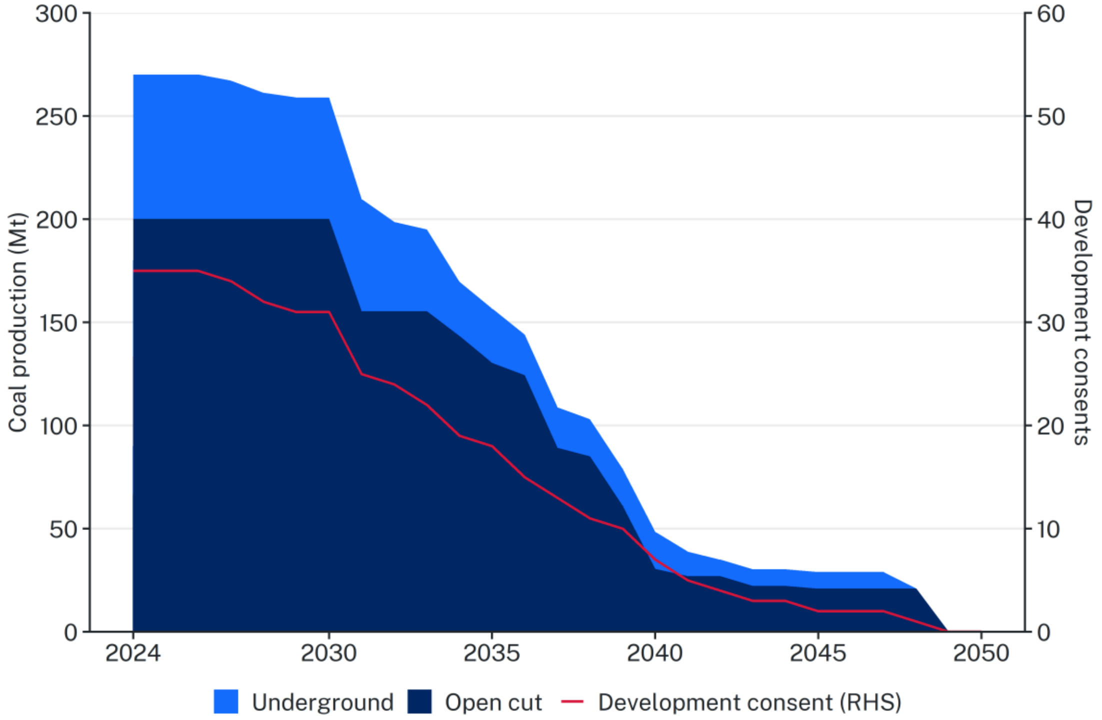
Strategic decisions by government that provide a more certain picture on the future of coal could, under these scenarios, supersede emissions pricing as the cost-effective pathway for the mining sector. In these circumstances, the state's resources would be reallocated over time toward less emissions-intensive 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.

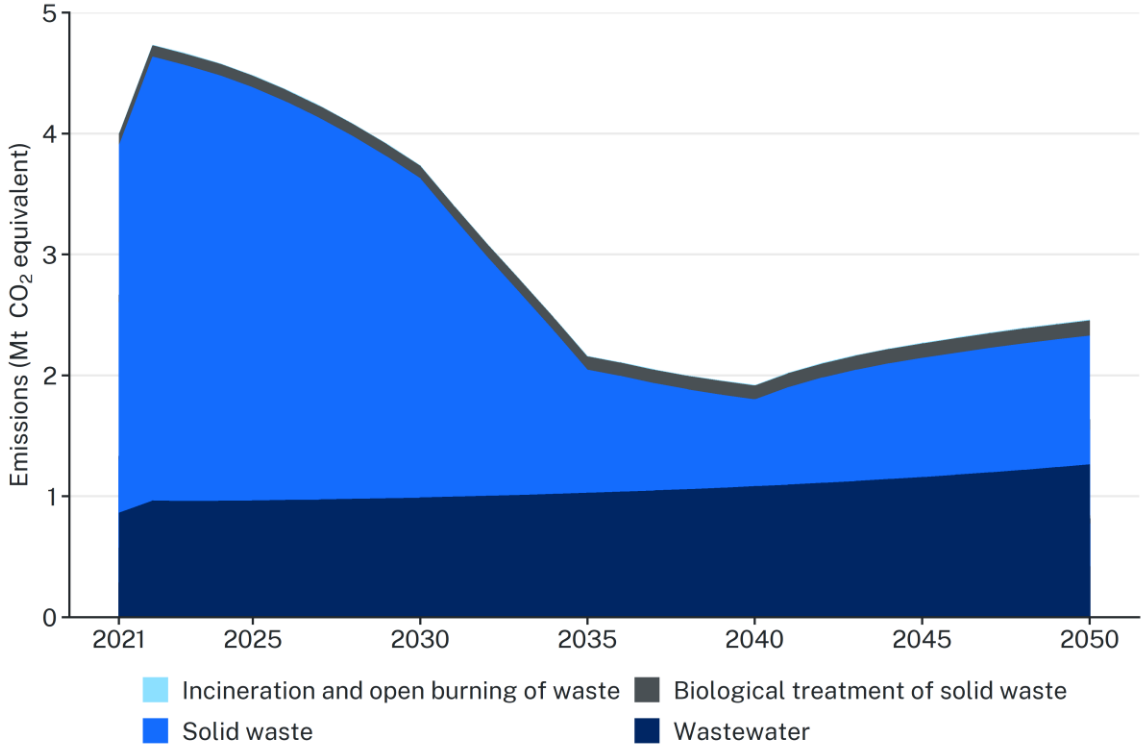
Waste emissions totalled 4.7 Mt CO_2-e in 2022-23, around 3.6 per cent of New South Wales' total emissions. These emissions are made up of three different streams:

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

Source: (CER, 2024a).

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