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Achieving the transition to net zero in Australia

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ABSTRACT/RÉSUMÉ

Title: Achieving the transition to net zero in Australia

Australia has committed to achieving net zero greenhouse gas emissions by 2050 and more recently outlined a more ambitious intermediate target for emission reductions by 2030. However, achieving these targets will be challenging given a historical reliance on coal generation and the presence of significant mining and agriculture sectors. It will require a rapid transformation of the electricity grid, significant emissions reductions in highly-polluting sectors such as industry and agriculture, and sufficient offsets generated by “negative emissions” technologies and practices to counterbalance any emissions that cannot be fully eliminated. At the same time, Australia is particularly vulnerable to the physical impacts of climate change, as the driest inhabited continent on the planet with the majority of the population living on the coasts. Further significant reforms are required to meet the emission reduction goals, support the reallocation of workers and adapt to climate change.

This Working Paper relates to the 2024 Economic Survey of Australia

https://www.oecd.org/economy/australia-economic-snapshot/

Keywords: Australia, climate change mitigation, agriculture, energy, transport

JEL: H23; Q15; Q18; Q42; Q48; Q58; R48

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Titre: Réaliser la transition climatique en Australie

L'Australie s'est engagée à réduire à zéro ses émissions de gaz à effet de serre d'ici 2050 et a récemment défini un objectif intermédiaire plus ambitieux de réduction des émissions d'ici 2030. Toutefois, atteindre ces objectifs ne sera pas facile en raison de la dépendance historique à l'égard de la production de charbon et de la présence d'importants secteurs minier et agricole. Cela nécessitera une transformation rapide du réseau électrique, des réductions d'émissions significatives dans les secteurs très polluants tels que l'industrie et l'agriculture, et des compensations suffisantes générées par des technologies et des pratiques "à émissions négatives" pour contrebalancer toutes les émissions qui ne peuvent pas être entièrement éliminées. En même temps, l'Australie, étant le continent habité le plus sec de la planète et la majorité de la population vivant sur les côtes, est particulièrement vulnérable aux effets physiques du changement climatique. Des réformes importantes sont nécessaires pour atteindre les objectifs de réduction des émissions, soutenir la réaffectation des travailleurs et s'adapter au changement climatique.

Ce document de travail concerne l'Étude économique de l’Australie de 2024

https://www.oecd.org/economy/australia-economic-snapshot/

Mots-clés : Australie, changement climatique, agriculture, énergie, transport

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Australia has committed to achieving net zero greenhouse gas emissions by 2050 and more recently outlined a more ambitious intermediate target for emission reductions by 2030. However, achieving these targets will be challenging given a historical reliance on coal generation and the presence of significant mining and agriculture sectors. It will require a rapid transformation of the electricity grid, significant emissions reductions in highly-polluting sectors such as industry and agriculture, and sufficient offsets generated by "negative emissions" technologies and practices to counterbalance any emissions that cannot be fully eliminated. At the same time, Australia is particularly vulnerable to the physical impacts of climate change, as the driest inhabited continent on the planet with the majority of the population living on the coasts. Further significant reforms are required to meet the emission reduction goals, support the reallocation of workers and adapt to climate change.

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Introduction

Australia has committed to reduce net greenhouse gas (GHG) emissions to zero by 2050, with an intermediate target to reduce GHG emissions by 43% below 2005 levels by 2030. Achieving these targets will be challenging given a historical reliance on coal generation and the presence of significant mining and agriculture sectors. It will require a rapid transformation of the electricity sector, the reduction of GHG emissions across sectors in an efficient way, and sufficient offsets generated by "negative emissions" technologies and practices to counterbalance any emissions that cannot be fully eliminated. Achieving net zero emissions will entail deep structural changes and require the reallocation of economic activity and labour across sectors.

The green transition will provide benefits for Australia in addition to contributing to global efforts to reduce carbon emissions. Co-benefits include improved health and biodiversity. Australia is well-placed to become a major producer of renewable power given its large land mass, ocean access, some of the best wind and solar resources in the world (Wood and Dundas, 2020), and its abundance of minerals critical to the green transition, representing significant opportunities in terms of job creation and new trade activities.

As the driest inhabited continent on the planet and with the majority of the population living on the coasts, Australia is highly vulnerable to climate change and related extreme events, such as extreme heat, heavy rainfall, coastal inundation, fire weather and drought. Australia will have to prepare and adapt for further global warming, which is already "locked-in" (Zhou et al., 2021), regardless of future actions to reduce global emissions.

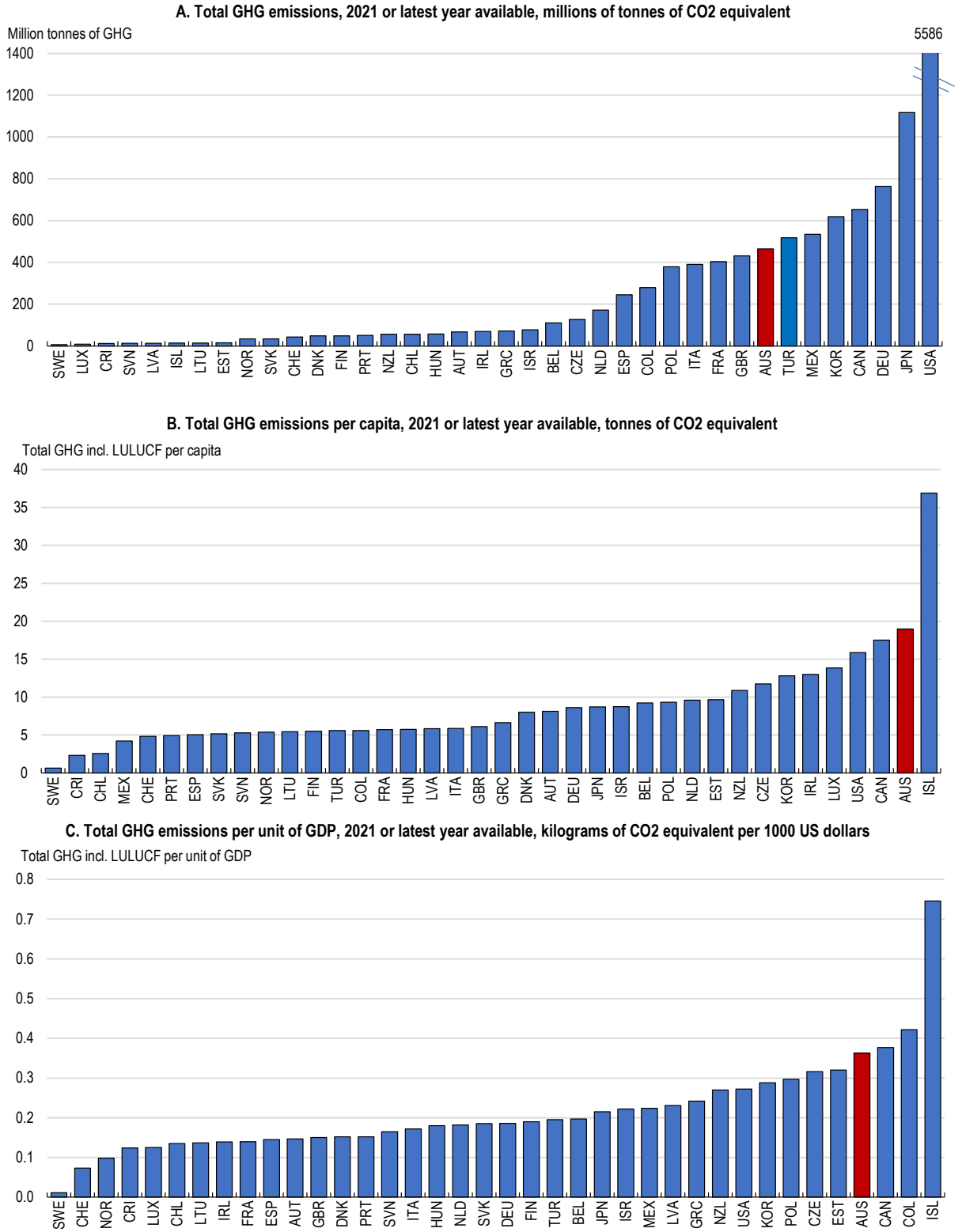
Net emissions have fallen over the past decade, but this has been in large part due to negative emissions from land use, land-use change and forestry (LULUCF), while total emissions excluding LULUCF only started falling in 2019. Achieving emissions targets will require significant further efforts. Under current policies, the electricity sector is the only sector where emissions are projected to fall significantly by 2030 from current levels, as renewable electricity replaces coal and gas-fired generation. Recent reforms have put Australia on the path to achieving its emissions reduction targets. As recommended in the previous Economic Survey, the Safeguard Mechanism, which regulates the emissions of Australia's largest emitters, has recently been reformed and is set to materially contribute to the decarbonisation of the economy. The government also announced a target to increase the share of low-carbon power generation by 2030, with 82% to come from renewable energy. These reforms have the potential to bring emissions reductions by 2030 close to the 43% reduction target (DCCEEW, 2022), but further policies may be needed to ensure that targets are met.

The current state of the transition to net zero emissions

Greenhouse gas emissions in Australia

Despite recent progress, Australia is currently among the highest emitters of greenhouse gases (GHG) in the OECD, due to a historical reliance on coal generation, its role as a major global supplier of energy commodities (including thermal and metallurgical coal), and the presence of significant industrial and agriculture sectors. In terms of total emissions, Australia ranks seventh in the OECD (Figure 1, Panel A). After accounting for its population, Australia ranks second in GHG emissions, with 19 tonnes of GHG emissions per capita in 2020 (Figure 1, Panel B). While Australia has made progress in decoupling emissions from economic activity, total GHG emissions per unit of GDP also remain well above the OECD average (Figure 1, Panel C).

Figure 1. Australia is among the highest emitters of greenhouse gases in the OECD



Note: Including land-use, land-use change and forestry (LULUCF).
Source: OECD Environment Statistics database.

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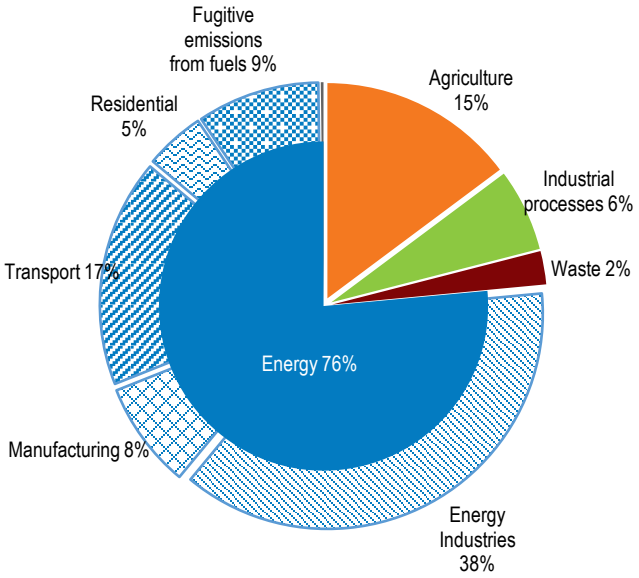
The energy sector is the main source of GHG emissions in Australia. In 2021, emissions from energy accounted for 76% of total emissions, followed by agriculture (15%), industrial processes (6%) and waste (2%) (Figure 2). Within the energy sector, electricity and heat generation account for the largest share of emissions (49%), followed by transport (22%), industry (22%) and buildings (6%). Emissions from electricity generation have fallen after a peak in 2016 as coal-based electricity generation has decreased (IEA 2023). Despite this decrease, almost half of GHG emissions from fuel combustion were due to coal in 2021 (45%), although this share has been decreasing since its peak in 2010 (IEA, 2023). GHG emissions from oil and gas, on the other hand, have been increasing, driven by rising energy consumption in the transport sector and the increasing role of gas in electricity generation.

Figure 2. Energy, transport and agriculture account for a large share of emissions

Share of emissions by sector, 2021 (%)



Source: OECD Environment Statistics.

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Australia's net GHG emissions have steadily declined since 2005, but the vast majority of Australia's decline in GHG emissions has been due to emission reductions in the land use sector as other emissions continued to rise. Between 2005 and 2020, annual emissions from land use, land use change and forestry declined by 123 million tonnes of CO_2 equivalent, and the sector has become a net sink since 2015. This reflected reductions in native forest harvesting and primary forest clearing, improved soil carbon management, the fostering of native vegetation growth and retention and improved fire management in Australia's Top End savannas.

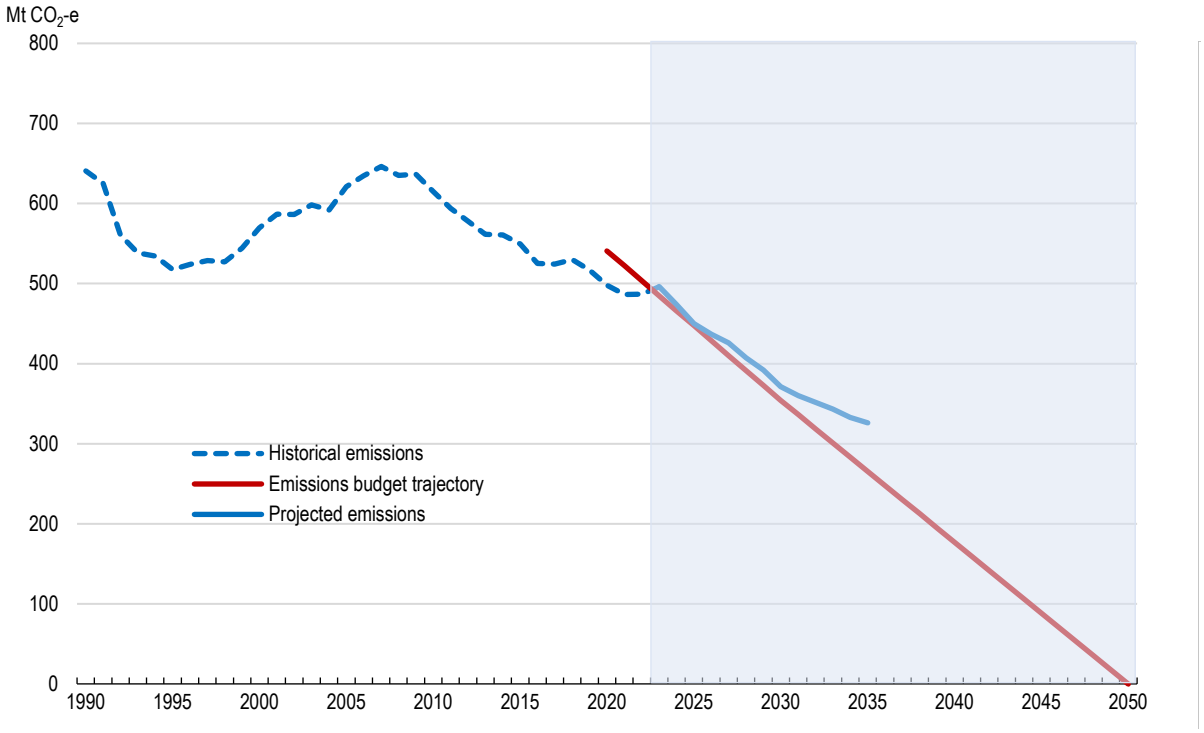
Declines in emissions from other sectors have been more limited. There have been increases in emissions from the transport sector and from fugitive emissions from fuels (largely deriving from the production of liquefied natural gas and coal for export) over the period. Emissions from agriculture declined by 13 million tonnes of CO_2 equivalent during the same period, mainly due to declining cattle stocks induced by extreme heat, while emissions from waste have declined by around 3 million tonnes.

To achieve the emissions targets, net emissions will have to decline at a quick pace over the next 20 years, and significant reductions will be required in all sectors. However, under current projections and policies, Australia is expected to fall short of its targets and therefore additional policy measures will be needed. Agriculture emissions are expected to rise as cattle stocks recover after their recent decline due to extreme

heat. Only emissions from electricity, industrial processes and waste are projected to significantly decline between 2020 and 2030 under current policies. Overall, the Department of Climate Change, Energy, the Environment and Water projects net GHG emissions to fall to 371 million tonnes of CO2-e by 2030 under current policies and assuming that the renewable electricity target of 82% by 2030 is met[2], falling short of the 2030 target to reduce emissions by 43% below 2005 levels by 2030, which would require emissions to fall to 354 million tonnes by 2030 (Figure 3).

Figure 3. Projected net emissions fall short of reduction targets

Historical and projected GHG emissions, Mt CO2-e



Note: including land-use, land-use change and forestry (LULUCF).
Source: DCCEEW (2022).

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Climate mitigation policies in Australia

Australia adopted the Climate Change Act in September 2022, which legislates a target of a 43% reduction in GHG emissions from 2005 levels by 2030, and net zero by 2050. These new targets are more ambitious than the previous emissions reduction target of 26%-28% between 2005 and 2030. The legislation also requires the Minister for Climate Change and Energy to prepare an Annual Climate Change Statement, informing the Parliament of progress on achieving emissions reductions, recent climate change policies, their effectiveness and their impacts, and the risks of climate change to Australia. These Statements must also take into account the advice of the Climate Change Authority, an independent body established in 2011 to provide expert advice to the government and conduct reviews and climate change research, which was given additional funding in the 2022-23 Budget. Finally, the Climate Change Act also provides for periodic reviews of the operation of the Act. The Department of Climate Change, Energy, the Environment

[2] This refers to the Department of Climate Change, Energy, the Environment and Water's "additional measures" scenario which takes into account the proposed reforms of the Safeguard Mechanism and a national renewable electricity target of 82% by 2030.

and Water (DCCEEW) was established in July 2022 to deliver the climate change and energy agenda and protect Australia's environment. This new department took over the energy functions from the Department of Industry, Science, and Resources.

Australia's climate mitigation policies are chiefly organised under the Powering Australia plan. The main components of this plan include: an 82% Renewable Electricity Target by 2030, the reform of the Safeguard Mechanism which regulates the emissions of the country's major industrial polluters (see Box 1 in the following section), the Powering the Regions Fund offering financial support for the decarbonisation in industry, the National Electric Vehicle Strategy aiming to encourage the uptake of Electric Vehicles (EVs), and the National Energy Performance Strategy, which focuses on increasing the energy efficiency and performance of the economy. The National Energy Transformation Partnership sets out how the government will collaborate with Australian jurisdictions, industry, communities, and unions.

The government announced in July 2023 that it will update Australia's Net Zero 2050 plan and underpin it with sectoral decarbonisation plans for the transport, agriculture and land, resources, industry, built environment and electricity and energy sectors. Such a long-term national strategy will provide greater certainty, with interim and sectoral emissions reduction targets, milestones and concrete actions. This will help Australians and Australian businesses make long-term decisions and could propel innovation in low carbon technologies and incentivise their adoption (Berestycki et al, 2022). Importantly, the updated Net Zero 2050 plan will also have to carefully consider the optimal sequencing of sectoral transition paths. For example, the decarbonisation and scaling up of the electricity network will need to be rapid enough to manage the pace of electrification of other sectors such as buildings and transportation, ensuring that network capacity and reliability are sufficient and that overall emissions fall in line with national targets.

Table 1. All states and territories have adopted climate targets

State or territory	Net zero commitments	Emissions reduction targets	Renewable energy targets
Australian Capital Territory	By 2045	50-60% by 2025 65-75% by 2030 90-95% by 2040 compared to 1990 levels	100% electricity since 2020 Transition away from gas by 2045
New South Wales	By 2050	50% by 2030 compared to 2005 levels	12 GW of renewable energy by 2030
Northern Territory	By 2050	No interim targets	50% by 2030 70% renewable electricity for Indigenous Essential Services communities by 2030
Queensland	By 2050	30% by 2030 compared to 2005 levels	50% by 2030 70% by 2032 80% by 2050
South Australia	By 2050	50% by 2030 compared to 2005 levels	100% by 2030 500% by 2050
Tasmania	By 2030	No interim targets	100% renewable electricity since 2020 150% by 2030 200% by 2040
Victoria	By 2045	28-33% by 2025 45-50% by 2030 75-80% by 2035 compared to 2005 levels	65% and 2.6 GW of storage planned by 2030 90% and 6.3 GW of storage planned by 2025
Western Australia	By 2050	80% emissions reduction target below 2020 levels for government operations No state-wide interim targets	State-owned coal-fired power stations, under Synergy, will be retired by 2030

Source: Department of Climate Change, Energy, the Environment and Water (2022).

Australian states and territories also set their own emissions reduction targets and policies. All states and territories currently have net zero commitments, ranging from 2030 in Tasmania to 2050 in New South Wales, the Northern Territory, Queensland, South Australia and Western Australia. All but the Northern Territory, Tasmania and Western Australia also have interim emissions reduction targets, and most states and territories have announced complementary renewable energy targets of differing ambitions (Table 1). In Tasmania, electricity generation is already 100% renewable and the state plans to further increase capacity in order to export electricity to the mainland. While state-level targets ultimately raise the level of ambition, the variety of emissions reduction targets and policies at the state and territory level implies different costs of emissions abatement. Strong coordination between the federal government and states and territories would help: the National Cabinet, established in response to the COVID-19 pandemic and composed of the prime minister and state and territory premiers and chief ministers, could be an appropriate setting for this coordination to occur.

Achieving Australia's emissions reduction targets

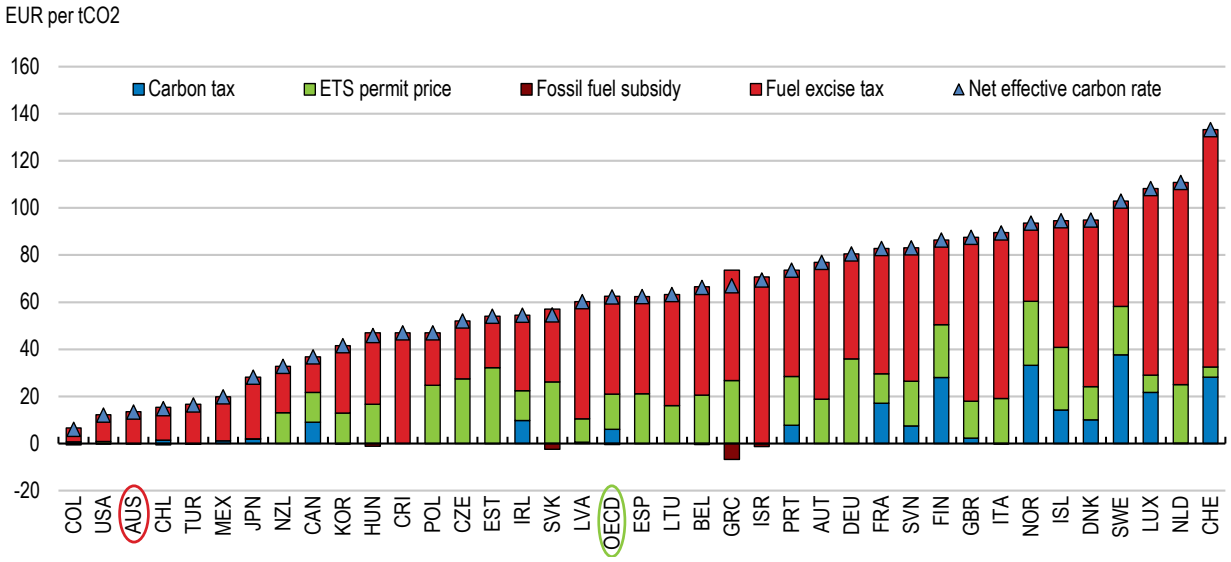
Meeting Australia's emissions reduction targets will be challenging, and additional measures are needed to achieve them according to the Department of Climate Change, Energy, the Environment and Water's current projections. A comprehensive policy mix will be required to achieve the transition in the most effective way, including emission pricing instruments, standards and regulations, and complementary policies to facilitate the reallocation of capital and labour towards low-carbon activities, to spur innovation and to offset any adverse distributional effects (D'Arcangelo et al., 2022). The current approach in Australia is based on limited carbon pricing, particularly through the taxation of fuels, and a comprehensive set of regulations, standards, and public investment tailored to specific sectors. One major tool to reduce emissions is the Safeguard Mechanism, which regulates the emissions of large emitters particularly in the industrial sector and which was recently reformed.

Cross-sectoral abatement policies

Carbon pricing can be an effective cross-sectoral measure to reduce GHG emissions by making low- or zero-carbon energy more competitive compared to high-carbon activities, incentivising shifts in production and consumption towards lower-carbon options, reducing demand for carbon-intensive fuels (D'Arcangelo et al., 2022; Arlinghaus, 2015; Martin et al., 2016), and mobilising private investment in low-emissions technologies (IMF/OECD, 2021). Effective carbon pricing can arise from fuel excise taxes, direct carbon taxes, or the use of tradeable carbon emission permits. Australia's carbon emissions were priced lower than in most other OECD countries in 2021, but similar to some other commodity exporters such as Chile, with the totality of carbon pricing arising from the fuel excise tax (Figure 4). The recent reforms of the Safeguard Mechanism, however, which introduce the possibility to generate tradeable carbon credits (see below and Box 2 for details), will effectively introduce further pricing of emissions in the covered sectors.

While economy-wide carbon prices can be a cost-effective tool to reduce emissions, effective decarbonisation strategies must balance cost-effectiveness with fairness and public acceptability. Carbon pricing has proven politically unpopular in Australia, although a cross-country OECD survey suggests that support for a carbon tax crucially depends on how revenues are used, with a majority of survey respondents (58-60%) supporting a carbon tax if revenue were used to subsidise low-carbon technology or to fund environmental infrastructure (Box 1). A carbon pricing mechanism was introduced in Australia in 2012, covering emissions from electricity generation, stationary energy, landfills, wastewater, industrial processes and fugitive emissions. Under the mechanism, liable entities were required to surrender one emissions unit for every tonne of carbon dioxide equivalent (CO_2-e) that they produced. The carbon pricing mechanism was repealed in 2014, and successive governments have ruled out further use of carbon pricing, opting for sectoral policies. In the absence of carbon pricing, sectoral policies should target the lowest-cost abatement opportunities in each sector to maximise their efficiency.

Figure 4. Carbon pricing has been limited in Australia



Note: Data are for 2021. Net effective average carbon rates are calculated as weighted average carbon prices across sectors net of fossil fuel support.
Source: OECD Net Effective Carbon Rates database.

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Box 1. Australian attitudes towards Climate Policies

The OECD led a survey in 2022 on the acceptability of climate policies, surveying over 40,000 respondents across twenty countries, including Australia. The survey sample includes 1,978 respondents from Australia and was designed to be nationally representative along the dimensions of gender, age, income, region, and area of residence (urban versus rural). Overall, the survey found that support for climate policies in the twenty covered countries is very dependent on their perceived distributional impacts and their perceived effectiveness. It also shows that information that specifically addresses these key concerns can substantially increase the support for climate policies in many countries.

In Australia, 77% of respondents agreed (somewhat to strongly) that "climate change is an important problem", and 76% agreed that Australia "should take measures to fight climate change". These proportions are only somewhat lower than in other high-income countries covered in the survey, where the average corresponding proportions were 84% and 81% respectively.

Survey results suggest that support for climate policies in Australia is generally lower than the average of high-income countries covered in the survey, and that support varies considerably depending on the climate policies considered. For example, Australians show relatively strong support for subsidies to low-carbon technologies (62% of respondents support it somewhat to strongly), mandatory and subsidised buildings insulation (70%), bans on polluting cars in city centres (53%), and green infrastructure programs (49%). On the other hand, they strongly oppose high taxes on cattle products (24% somewhat to strong support), taxing fossil fuels without revenue earmarking (36%), and a carbon tax with lump-sum cash transfers to all households (34%).

In Australia as in other countries in the survey, support for carbon taxes without revenue earmarking is low compared to other climate policies, but support rises depending on the proposed use of revenue. While only 29-34% of respondents support carbon taxes with revenue used to reduce corporate income taxes or provide equal cash transfers to all households, support for carbon taxes increases to 58-60% if revenue is used to subsidise low-carbon technology or to fund environmental infrastructure. Majority support also

exists in Australia for a carbon tax with revenues being recycled to low-income households or to lower personal income tax.

Figure 5. Support for different climate policies varies greatly

Share of respondents who support climate change policies (somewhat to strongly)

	High-income												Middle-income								
	Australia	Canada	Denmark	France	Germany	Italy	Japan	Poland	South Korea	Spain	United Kingdom	United States	Brazil	China	India	Indonesia	Mexico	South Africa	Turkey	Ukraine
Main Policies Studied																				
Green infrastructure program	57	49	56	53	57	42	78	48	58	68	71	54	50	78	77	82	80	80	84	73	76	69
Ban on combustion-engine cars	43	35	47	41	28	32	54	41	44	52	54	45	39	65	60	72	77	65	67	53	62	58
Carbon tax with cash transfers	37	34	41	30	29	28	47	35	36	53	44	34	33	59	47	80	71	67	55	52	55	39
Transportation Policies																				
Ban on polluting cars in city centers	60	53	60	66	57	50	76	64	61	52	64	65	49	71	65	73	74	85	72	66	60	67
Ban on combustion-engine vehicles w. alternatives available	48	38	47	42	42	41	58	51	48	58	57	52	44	68	60	78	77	72	66	62	64	63
Tax on flying (+20%)	45	35	44	60	46	53	41	47	44	42	44	46	33	52	39	61	64	68	51	43	45	36
Energy Policies																				
Subsidies to low-carbon technologies	67	62	65	67	56	64	79	69	75	71	73	65	57	73	77	75	68	79	66	75	75	68
Mandatory and subsidized insulation of buildings	66	70	64	70	64	60	73	59	72	72	71	70	53	75		80				73	75	75
Funding clean energy in low-income countries	54	49	50	53	48	48	76	53	55	57	65	51	50	73	63	71	75	81	74	76	66	78
Tax on fossil fuels ($45/tCO2)	36	36	40	43	31	31	38	35	27	42	39	38	34	48	35	58	64	58	41	38	52	28
Food Policies																				
Subsidies on organic and local vegetables	56	42	50	59	52	56	71	46	73	62	65	49	43	68	62	79		77	58	59	80	58
Ban of intensive cattle farming	42	32	41	31	55	49	64	17	44	44	43	50	36	39	38	50		45	46	28	32	25
Removal of subsidies for cattle farming	34	31	33	32	28	38	42	16	34	31	42	37	38	39	43	47		51	47	27	31	22
A high tax on cattle products, doubling beef prices	30	24	27	31	29	40	37	19	30	26	31	31	31	36	33	48		49	37	30	26	24
Support for Carbon Tax With:																				
Funding environmental infrastructures	63	60	48	60	65	60	76	56	68	78	69	63	56	75	78	76	71	81	73	79	73	69
Subsidies to low-carbon tech.	63	58	49	52	57	66	76	68	71	79	69	59	53	73	74	79	68	79	71	78	66	65
Reduction in personal income taxes	57	52	48	38	62	54	72	64	69	62	67	52	49	69	69	74	68	74	69	68	66	64
Cash transfers to the poorest households	53	51	48	41	55	47	68	54	50	59	63	57	46	73	67	82	69	86	66	65	82	62
Cash transfers to constrained households	50	50	42	36	55	47	62	47	39	62	61	52	44	64	59	69	63	74	59	60	65	61
Tax rebates for the most affected firms	48	41	41	38	52	34	66	49	61	59	55	41	43	62	59	72	65	68	54	63	55	56
Reduction in the public deficit	48	40	39	34	49	39	66	50	56	48	62	44	48	63	62	72	65	70	61	62	57	52
Equal cash transfers to all households	38	37	38	27	45	31	42	43	37	42	44	33	38	61	45	70	64	76	62	57	59	53
Reduction in corporate income taxes	37	29	32	24	37	25	55	38	48	48	50	26	29	58	54	67	60	67	61	50	60	42

Source: Dechezleprêtre, A. et al. (2022), "Fighting climate change: International attitudes toward climate policies", OECD Economics Department Working Papers, No. 1714, OECD Publishing, Paris, https://doi.org/10.1787/3406f29a-en.

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The main policy tool in Australia to reduce GHG emissions from large industrial facilities is the Safeguard Mechanism. The Mechanism sets limits (called baselines) on the emissions intensity of industrial facilities that emit more than 100,000 tonnes of CO_2-e per year, of which there are more than 200 and which are responsible for close to 28% of Australia's total emissions. In comparison, the European Union's Emissions Trading System covers facilities emitting more than 25,000 tonnes of CO_2-e per year. The Safeguard Mechanism covers facilities in the extractive industries sector, such as coal and iron ore mines, and in the industrial processes sector, including manufacturing and chemical plants. It also applies to the electricity sector, although a single baseline is set for the whole sector (as opposed to individual generators).

The Safeguard Mechanism was recently reformed to be more consistent with Australia's revised emission reduction targets (see Box 2 for details on this reform). This reform introduces a number of fundamental changes. First, it introduces below-baseline crediting, so that firms that do not use their full allowance earn a Safeguard Mechanism Credit that can be traded with other members of the scheme or used in later years to exceed baselines. This incentivises the reduction of emissions beyond site-specific baselines and helps to equalise marginal abatement costs with other producers. Second, the reform has reset the baselines, eliminating all the current headroom under them, which in many cases had been set well above facilities' emissions intensities. These baselines will now decline steadily each year. Finally, the reforms also introduced special considerations for new facilities entering the Safeguard Mechanism, which will be

treated at a higher standard than existing facilities, and for facilities that are both highly emissions-intensive and trade-exposed, which will be able to apply for slower baseline decline rates. These reforms are welcome and could deliver significant emissions reductions. DCCEEW projections estimate that they will deliver around 46 Mt CO_2-e in additional emissions reductions by 2030 compared to the baseline scenario.

Box 2. The 2023 reform of the Safeguard Mechanism

The Safeguard Mechanism is a set of regulations that apply to all industrial facilities in Australia that emit more than 100,000 tonnes of CO2-e per year. It sets individual limits, known as baselines, on the net emissions of the more than 200 industrial facilities that it covers, which together emit close to 28% of Australia's total GHG emissions. It covers a broad range of industrial sectors, including electricity generation, mining, oil and gas extraction, manufacturing, transport, and waste. The Safeguard Mechanism was legislated in 2014 and has been in place since 2016. It was recently reformed following a period of consultation, culminating in the passage of *The Safeguard Mechanism (Crediting) Amendment Bill 2023* in March 2023. The reforms became effective in July 2023.

How the Safeguard Mechanism works

The Safeguard Mechanism limits industrial emissions by establishing emissions baselines (or ceilings) for every individual facility it covers. Baselines are set in terms of facilities' emissions intensities (emissions per unit of output), therefore on any given year the effective ceiling on an individual facility's absolute emissions is calculated as the emissions intensity baseline (or ceiling) multiplied by the facility's output. This means that covered facilities can raise their emissions by producing a larger volume, as long as the emissions intensity of the product is below the baseline.

Facilities that exceed their baselines must purchase and surrender domestic carbon offsets – Australian Carbon Credit Units (ACCUs) generated by Australia's carbon crediting scheme (ACCU Scheme)– for the exceeding amount.

To date, baselines set by the Clean Energy Regulator have generally been set higher than facilities' emissions and have therefore had little effect on emissions.

The electricity sector is treated differently than other sectors covered by the Safeguard Mechanism. Because electricity production is centrally coordinated, the Safeguard Mechanism applies a common baseline for the whole electricity sector.

The reformed Safeguard Mechanism

The *Safeguard Mechanism (Crediting) Amendment Bill 2023* enacted a number of reforms to the Safeguard Mechanism, which have been in place since 1 July 2023. These reforms were made with the objective of requiring the large industrial facilities covered under the Safeguard Mechanism to deliver a proportional share of Australia's new emissions reduction targets.

New baselines

The reform of the Safeguard Mechanism retains the current framework of emissions intensity baselines for each covered facility, as opposed to absolute emissions baselines.

Baselines for existing facilities will initially be set using site-specific emissions intensity values, which will eliminate the current headroom in the system. The emissions intensity values used to calculate site-specific baselines will then gradually transition towards industry average emissions intensity values by 2030. This is meant to incentivise production to occur in facilities with below-average emissions intensity.

Baselines will decline at a rate of 4.9% each year to 2030. A reserve has also been built into baseline decline rate calculations to ensure the 2030 target is met. The reserve accounts for any higher-than-expected production growth at new and existing facilities and any higher-than-expected use of the trade exposed baseline adjustments.

Post-2030 decline rates would be set in predictable five-year blocks, after updates to Australia's Nationally Determined Contribution (NDC) under the Paris Agreement. Periodic baseline setting would involve consultation and take advice from the CCA and the latest Annual Climate Change Statements to Parliament.

Safeguard Mechanism Credits (SMCs)

The reform introduces Safeguard Mechanism Credits (SMCs), which facilities will automatically generate when their emissions are below their baseline. These new credits can be held, sold, or used to offset above-baseline emissions under the Safeguard Mechanism. They come in addition to the already-existing Australian Carbon Credit Units generated by the ACCU Scheme which remain eligible under the Safeguard Mechanism

If a facility uses ACCUs equal to more than 30% of its baseline, it must submit a statement to the Clean Energy Regulator setting out why onsite abatement hasn't been undertaken.

Facilities will also be able to bank and borrow SMCs until 2030 in order to provide flexibility on the speed of abatement.

Treatment of new facilities

The baselines for new industrial facilities will be set at international best practice levels and will decline at the same rate as existing facilities. This is meant to take into account that new facilities will have access to the latest technologies and can achieve higher levels of emissions performance than existing facilities using legacy technologies.

Treatment of emissions-intensive, trade-exposed (EITE) facilities

Facilities that are both highly emissions-intensive and trade-exposed will be eligible to access the AUD 1.9 billion Powering the Regions Fund (PRF). Within the PRF, the Government will support trade-exposed Safeguard facilities to invest in low emissions technology through the AUD 600 million Safeguard Transformation Stream, and will also support industries providing critical inputs to clean energy industries (including steel, cement, lime, aluminium and alumina) through the AUD 400 million Critical Inputs Fund.

Trade-exposed facilities facing an especially elevated risk of carbon leakage will be able to apply for a slower baseline decline rate.

Review in 2026-2027

The policy settings of the Safeguard Mechanism will be reviewed in 2026-27. The review will consider a number of issues including the setting of baselines and their decline rates, the suitability of the differential treatment of emissions-intensive, trade-exposed activities, and the suitability of the various flexibility mechanisms in the system. The CCA will be required to advise the Government on the impact of the reforms on abatement and whether additional changes are required.

Source: Department of Climate Change, Energy, the Environment and Water.

While these reforms go in the right direction, further reforms to the Safeguard Mechanism may be needed to achieve emission reduction targets. First, the 2023 reform maintained baselines in terms of emissions intensity as opposed to total emissions. This means that covered facilities can raise their total emissions if they produce a larger volume, as long as the emissions intensity of the product is below the baseline.

Industrial emissions are therefore not guaranteed to fall in line with national emissions reduction targets, which are set in terms of the absolute quantity of emissions, although regular reviews might lead to a tightening of the baselines if required. Second, baselines set in terms of emissions intensity combined with below-baseline crediting could also provide incentives for facilities with below-baselines emissions intensity to increase their production to generate Safeguard Mechanism Credits, which could eventually lead to an over-supply of these Credits.

The *Safeguard Mechanism (Crediting) Amendment Bill* 2023 provides for another review of the functioning of the Mechanism in 2026-27. This would be an appropriate time to further assess the impact of recent reforms. In particular, if industrial emissions do not fall in line with emissions reduction targets and Australia's commitments under the Paris Agreement, baselines under the Safeguard Mechanism should be switched to baselines defined in terms of absolute emissions (as opposed to emissions intensity), which combined with below-baseline crediting, would bring the Safeguard Mechanism closer to a cap-and-trade system and be better aligned to policy objectives set in terms of the overall level of emissions. This review could also consider whether to set a floor on the price of ACCUs and Safeguard Mechanism Credits, as in the United Kingdom, which could reinforce incentives and increase certainty, and whether to broaden the coverage of the Safeguard Mechanism to other sectors. It will also be important to assess whether the baseline decline rates are appropriate, and whether the special treatment of emissions-intensive, trade-exposed activities and new facilities should not be tightened. It is important to ensure that the Safeguard Mechanism requirements are properly enforced and that penalties for exceeding baselines provide a sufficient deterrent.

Given that industrial facilities under the Safeguard Mechanism can meet their baselines by using carbon offsets (Box 2), it is imperative to ensure their credibility, integrity and additionality. In addition to Safeguard Mechanism Credits generated by industrial facilities that overachieve their Safeguard Mechanism emissions baselines, projects in other sectors that generate abatement with methodologies recognised by Australia's Clean Energy Regulator can earn Australian Carbon Credit Units (ACCUs). ACCU prices have increased somewhat since the Safeguard Mechanism was reformed, and traded at around AUD 32 in August 2023, roughly in line with carbon credit prices in California but around a third of the price of European Union Carbon Permits. There has been criticism of the ACCU generation process as regards to the effectiveness and additionality (that is, whether projects result in carbon abatement that is unlikely to occur in the ordinary course of events) of the abatement projects it credits (Australian National University, 2022; Macintosh, 2022). A recent independent Review of Australian Carbon Credit Units highlighted these issues and produced a list of 16 recommendations to improve the integrity of the scheme, which the government has supported in principle. These include recommendations to improve transparency and remove restrictions on data sharing, and to improve the process of defining new methods that would be eligible for carbon credits. While the recent reform of the Safeguard Mechanism included 3 amendments to the ACCU scheme, the government should proceed with the full implementation of the recommendations in the Review of ACCUs. This should strengthen confidence in the transparency and integrity of ACCUs. In the latest Federal Budget, the government provided AUD 18.1 million over two years to implement priority reforms to the ACCU, including the establishment of the Carbon Abatement Integrity Committee to ensure the integrity of methods covered by the system.

The rest of this section covers policies to reduce emissions in Australia's main polluting sectors: electricity generation, extractive industries, industrial processes, transport, agriculture and buildings. In the case of the extractive industries and industrial processes sectors, the Safeguard Mechanism already discussed in this section is the main policy tool to reduce emissions from large facilities, but further policies will be needed to achieve emissions reductions in smaller facilities not covered by the mechanism.

Electricity generation

Australia's energy sector is at the heart of the transition to net zero. Energy production is responsible for the majority of Australia's GHG emissions, and the power sector will be key to reduce emissions in other sectors such as transport and industry through electrification. Achieving the transition to net zero will require increasing total electricity generation capacity to satisfy increased demand from the electrification of certain sectors, large investments in transmission infrastructure, and a quick transition towards a majority of renewable electricity generation. The scale and urgency of these transformations will require careful planning and coordination across policymakers and levels of government, strong policies in the energy sector and large investments in electricity generation capacity and transmission to manage higher electricity use and more variable output from renewables. The abundance of sun, wind and land means Australia can generate large volumes of renewable electricity. The abundance of critical minerals also provides an opportunity for Australia to play a key role in supply chains for net zero technologies like batteries.

Table 2. Australia's state and territory renewable energy targets and policies up to 2030

State	% of demand	Renewable energy target	Policy measure(s)
New South Wales		24 600 GWh by 2030	Net Zero Plan Stage 1: 2020-2030 Electricity Infrastructure Roadmap
Queensland (large-scale)	18% of electricity generated by renewables	70% of renewables by 2032 and 80% by 2035 (announced in September 2022)	Climate Action Plan 2020-2030 Plans to convert coal-fired power plants to renewable hubs by 2035 under a AUD 62 billion clean energy plan, including through reverse auctions.
Victoria	26% of electricity generated by renewables	25% by 2020, 40% by 2025 (committed in 2017) 50% by 2030 (committed in 2019) 65% by 2030, 95% by 2035 (announced in 2022)	Climate Change Strategy Reverse auction to fund renewable energy generation projects (>900 MW in total) and successful bidders enter into contracts for the difference.
South Australia	Demand covered 100% by renewables on 180 days in 2021	100% net renewables by 2030 500% by 2050 (become exporter	Climate Change Action Plan 2021-2025 No market mechanism. Government funding for renewables and storage
Northern Territory		50% by 2030 announced in 2017	Climate Change Response: Towards 2050 In January 2019, the Northern Territory Government entered into power purchase agreements to buy electricity from two new solar farms.
Australian Capital Territory	Achieved 100% renewables in 2020	100% by 2020 (committed in 2016)	Climate Change Strategy 2019-2025 Reverse auction to fund renewable energy generation projects (650 MW in total) and successful bidders enter into contracts for the difference.
Tasmania	Achieved 100% renewables in 2020	15 750 GWh by 2030, 21 000 GWh by 2040 =200% announced in 2020	Climate Change Action Plan 2017-2021 No market mechanism. A range of complementary measures, including government investment in existing hydropower assets.
Western Australia		None (80% of emissions reductions by 2030, coal retirements by 2030, AUD 3.8 billion investment plan in renewable power)	Climate Change Policy

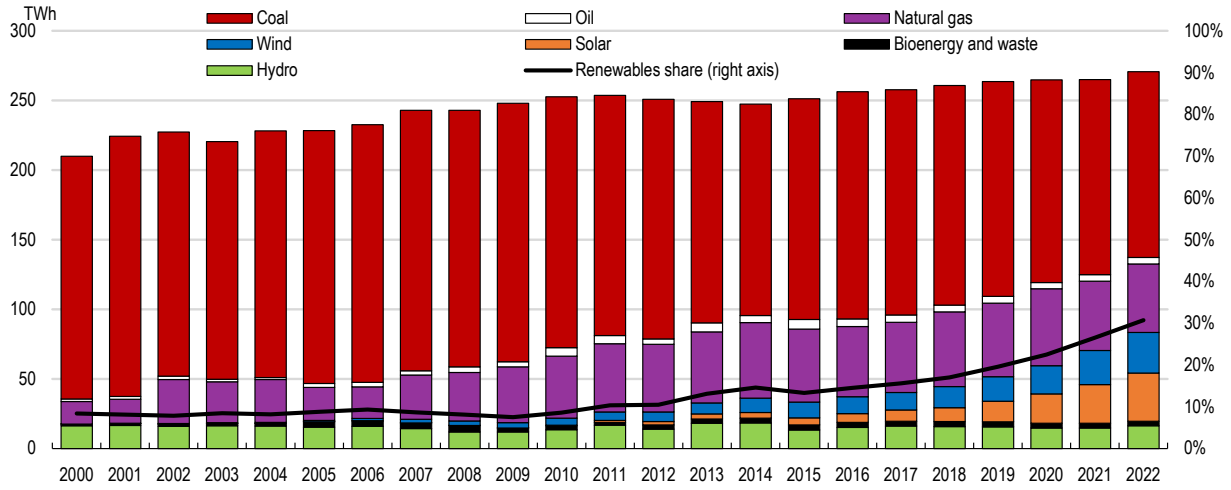
Note: GWH = gigawatt hour; MW = megawatt.
Source: CCA, (2020) IEA updates.

The Australian government has announced a target of 82% renewable electricity generation by 2030. In addition, state and territory renewable energy targets and related policy measures including reverse auctions, feed-in premiums and power purchase agreements have been upgraded in recent years and have been an important driver of increased renewable generation (see Table 2). In August 2022, federal, state and territory energy ministers established a National Energy Transformation Partnership (NETP) to coordinate action and identify priorities for the transformation of the Australian energy sector. A first action of the NETP will be to introduce an emissions reduction objective into the national energy objectives, which will serve as a basis for further policies and regulations by Australia's three energy market bodies – the Australian Energy Market Commission (AEMC), the Australian Energy Market Operator (AEMO) and the Australian Energy Regulator (AER). The NETP also aims to help speed up the deployment of transmission lines by identifying critical transmission projects to speed up their delivery and ensure community consultation.

Renewable electricity generation has greatly increased in recent years, quadrupling between 2000 and 2021 (albeit from low levels), mainly driven by strong increases in solar and wind electricity generation, which in 2022 accounted for 12.8% and 10.7% of total electricity generation respectively (Figure 6; IEA, 2023). One in three households in Australia have rooftop solar photovoltaic installations, the highest share in the world, and these households can receive feed-in tariffs for any unused electricity sent back to the grid. Nevertheless, the share of all renewables in total electricity generation remains below the OECD average, at 30.8%. Achieving the national target of 82% renewable electricity generation by 2030 and managing the fluctuations in renewable generation will require further reforms in the National Energy Market, one of the largest interconnected electricity markets in the world which connects the six eastern and southern states and territories and delivers around 80% of all electricity consumption in Australia. Given that states have constitutional power with regard to the electricity generation mix, strong cooperation and coordination of federal, state and territory policies will be essential. State-based investment schemes and incentives programmes should be carefully coordinated, informed by a national plan providing greater clarity on the timing of capacity additions and the retirement of coal generation.

Figure 6. The share of renewable electricity generation has risen but more progress is needed

Electricity generation in Australia by source, TWh



Note: data for 2022 are provisional.
Source: IEA World Energy Statistics.

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Despite its potential, offshore wind electricity generation remains a nascent industry in Australia, with costs remaining high (IEA, 2023). Both Victoria and South Australia are currently promoting offshore wind areas, and Victoria has set offshore wind capacity targets (2 GW by 2032, 4 GW by 2035 and 9 GW by 2040).

The government has put in place a number of policies to fast-track the development of the offshore wind industry including the Offshore Electricity Infrastructure Act 2021, which provides the legal framework to enable the construction, installation, commissioning, operation, maintenance and decommissioning of offshore electricity infrastructure, and the Offshore Electricity Infrastructure Regulations 2022. The experience of countries that have achieved significant offshore wind capacity, such as Denmark, where 18% of electricity demand is met by offshore wind generation, suggest that careful spatial planning, including of grid connections, and a streamlined licensing system are important for the development of the offshore wind industry (Box 3).

Box 3. The development of offshore wind capacity in Denmark

The world's first offshore wind farm was commissioned in Denmark in 1991, but it took three decades of sustained support to get to the point where it met 18% of Danish electricity demand in 2019. Policy measures have been central in increasing deployment and bringing down costs.

- Sustained support for wind research, development and deployment, with significant subsidies in the late 1970s and 1980s and increasing funding throughout the 2000s, peaking at DKK 618 million in 2013.
- Quantitative targets for wind energy in energy plans for 2000, 2005 and 2020, all exceeded.
- A spatial planning committee for offshore wind was established in 1995 to ensure coordinated development. Grid connection for large offshore wind farms is planned, procured, operated and paid for by the transmission system operator and can contribute to the broader network and interconnection.
- The Danish Energy Agency is the single body responsible for issuing all required licenses. The average consent processing time of 16 months is considerably shorter than in the Netherlands, Spain or Germany.
- Feed-in tariffs determined by competitive tender, which peaked at DKK 1.05/kWh for the Anholt wind farm in 2013, falling to DKK 0.372/kWh for the Kriegers Flak project scheduled to be operational in 2021.
- Development sites for government-run tenders are de-risked: prior to tender there is a fully approved Environmental Impact Assessment of the offshore area and possible grid solutions.

Source: OECD (2021c).

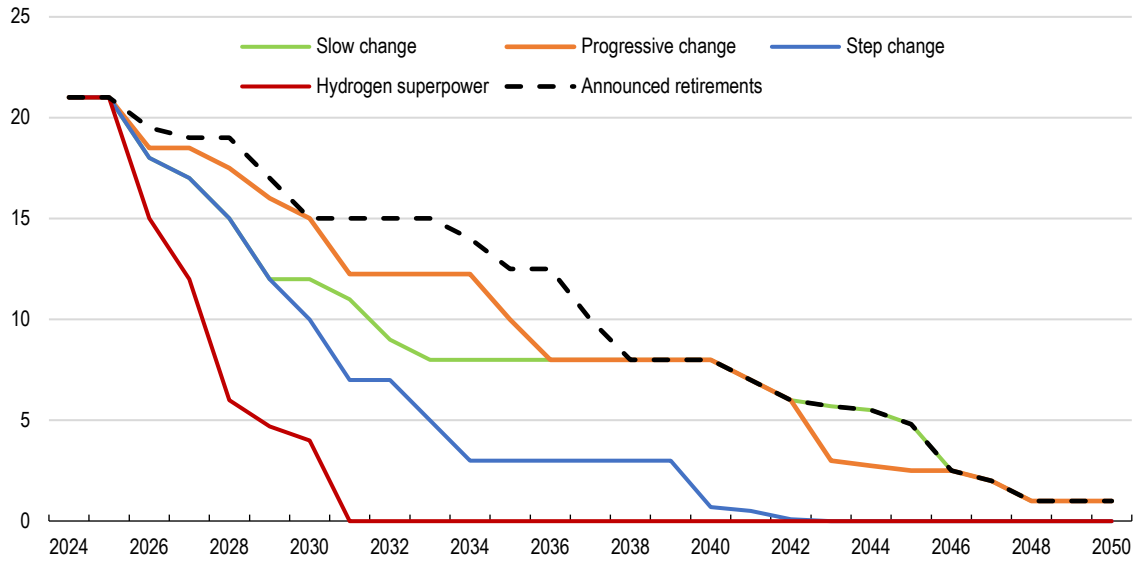
Australian authorities have in recent years enacted a series of reforms to support electricity security and the integration of rising shares of variable renewables into the electricity system (IEA, 2023). These include the introduction of an integrated system plan with renewable energy zones and transmission priority projects, adjustments to short-term trading, the introduction of the five-minute settlement (which allows for changes to metering, settlement and bidding processes), and a formal demand response at the wholesale level. The deployment of batteries has also reinforced the stability of the National Energy Market, and additional 1 700 MW of battery capacity is committed to enter the NEM by 2025. Pumped hydro storage is also expected to play an important role, and the Snowy Hydro scheme is set to be expanded over the next few years. The 2016 South Australia blackout and the June 2022 electricity crisis illustrate the need for system stabilisation mechanisms. The Australian Energy Market Operator forecasts that more than 300% of additional investment in utility-scale storage will be required to manage real-time power system stabilisation more efficiently and support cost-effective load shifting compared to current levels.

Australia's renewable electricity targets also imply a fast decline in coal power generation. However, uncertainty remains over the speed of retirement of coal generation. Announced coal plant retirements by coal plant owners are currently not in line with the Australian Energy Market Operator's (AEMO) ambitious

step change scenario under the Integrated System Plan 2022, under which 16 GW of thermal coal generation would be retired over the next two decades (Figure 7). Australia has also not joined more than 40 other countries committing to phase out coal power at the 2021 COP26 summit, including large coal power using countries such as South Korea, Indonesia, Vietnam, and Poland, Greater certainty is required to plan for the retirement of thermal coal generation, address its impact on the reliability of the power sector, and spur investment in power generation from other sources. The Australian government currently requires a 3.5-year notice period for coal-fired power plant owners to notify the government of a plant closure. Greater coordination between states, the AEMO and power plant operators will be necessary to ensure an orderly retirement of coal power generation.

Figure 7. Announced retirements of coal-fired generators are not consistent with climate goals

Scheduled closure profile of coal-fired generators in Australia by scenario, available coal capacity (GW)



Source: AEMO (2022).

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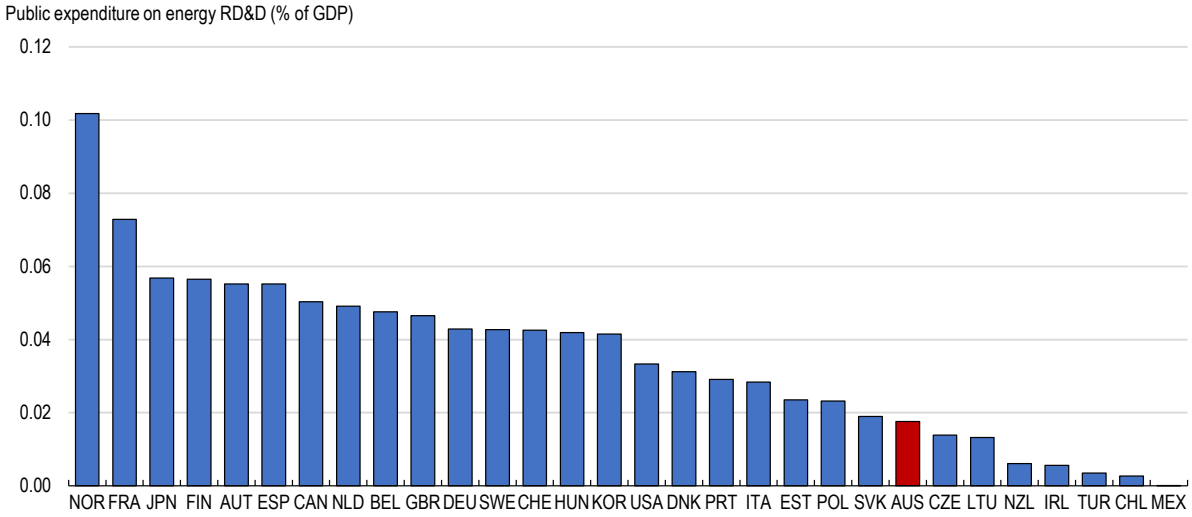
The Australian Government has committed around AUD 23 billion (1% of GDP) until the end of 2025 towards transforming the country's energy system, including AUD 20 billion for the Rewiring the Nation programme to increase renewable energy capacity and to invest in key transmission projects through the Clean Energy Finance Corporation. Under the program, the government will provide AUD 1.5 billion in concessional financing for renewable projects in Renewable Energy Zones, with fast-track regulatory processes to support their quick deployment. The government also recently announced a Capacity Investment Scheme, a guarantee scheme to support the development of renewable generation and storage which is expected to unlock AUD 10 billion in investment. Increased clean energy funding, the use of power purchase agreements and projects announced in Renewable Energy Zones could expand Australia's renewable energy capacity by at least 85% according to the IEA (2023). Australia should stand ready to provide further policy support and accelerate the planning and implementation of renewable energy projects to ensure that renewable energy targets are met.

The government has identified the development of clean energy technologies as a key component of the transition to net zero. One important aspect is the development and deployment of carbon capture, utilisation and storage to reduce emissions from coal power generation. Strong institutions are already in place to support these aims. The Australian Renewable Energy Agency provides grants for research, development, demonstration, deployment and early-stage commercialisation of renewables technology. The Clean Energy Finance Corporation facilitates the financing of clean energy projects through a variety

of instruments including co-financing, project finance, corporate loans, climate bonds and equities. However, Australia's public spending on energy RD&D, at 0.018% of GDP in 2023, is significantly smaller than the IEA average (Figure 8). Most of this public expenditure was on commercialisation (72%), while only 23% was on R&D and 6% for demonstration (IEA, 2023c). To date, carbon capture and storage technologies have received the highest amount of public support but have yet to demonstrate their effectiveness in reducing emissions at scale (Browne and Swann, 2017; Productivity Commission, 2023). Australia also provides a volume-based R&D tax credit to incentivise private investment in R&D (not only energy-related), for which there is significant uptake by SMEs (OECD, 2021). Despite this tax relief measure, total government support to business R&D in Australia, at 0.15% of GDP, is below the OECD average. According to the IEA, energy R&D funding in Australia does not yet match the ambition for reaching net zero by 2050 (IEA, 2023). In the absence of wider carbon pricing, more investment is needed in the development and demonstration of critical net zero technologies, particularly in hard-to-abate sectors. The government should consider scaling up and refocussing its RD&D funding programs towards the development and demonstration of clean energy and energy-efficiency technologies.

Figure 8. Public spending on energy RD&D is low in Australia



Note: 2023 or latest year available.
Source: IEA Energy Technology RD&D Budgets database.

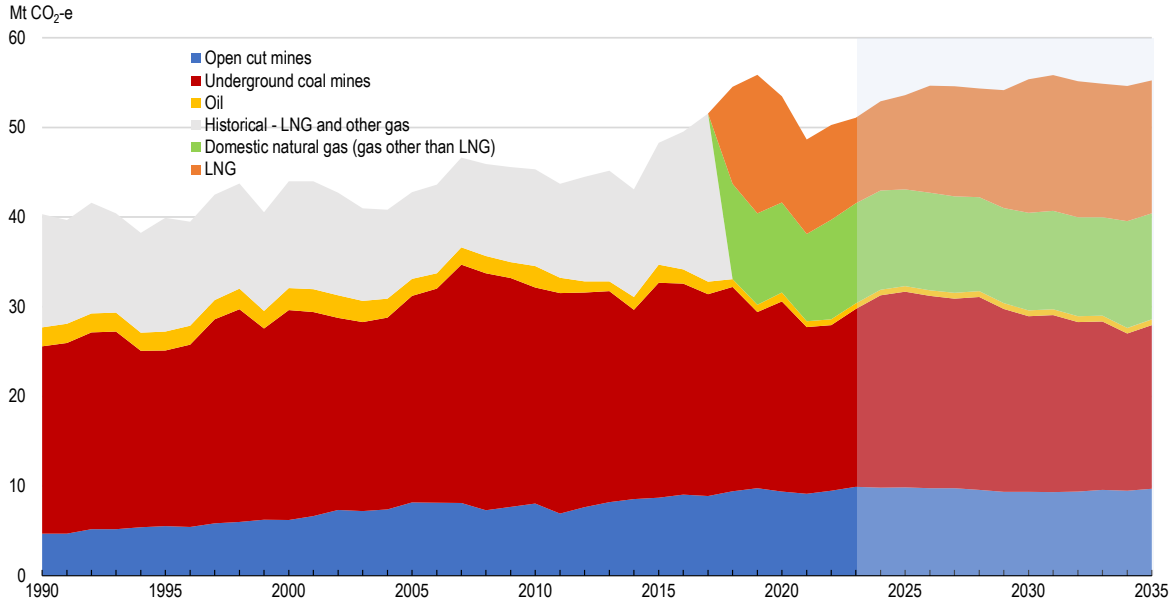
StatLink https://stat.link/brvgoh

Extractive industries

After combining direct and indirect GHG emissions from purchased electricity, mining is by far the economic sector with the largest percentage increase in emissions since 1990. Combined emissions from mining rose steadily by 138% between 1990 and 2020. According to DCCEEW's baseline projections, these mining emissions are expected to decline by 8% between 2020 and 2030 as coal production falls, mining equipment is electrified (displacing diesel) and the electric power grid is greened. Fugitive emissions are released during the extraction, processing, and transport of fossil fuels. These emissions have steadily increased since the 1990s to reach 53 Mt CO_2-e in 2020, and mainly arise from coal, which accounted for 57% of all fugitive emissions (Figure 9). Fugitive emissions from coal are driven by coal production, mining emissions intensity and the quantity of methane capture: in 2020, 52% of the methane generated from underground coal mines was captured for flaring and electricity generation (Department of Industry, Science Energy and Resources, 2022). Fugitive emissions from oil and gas extraction are the second major source of fugitive emissions in Australia, accounting for 22.9 Mt CO2-e in 2020, or 43% of

fugitive emissions. Fugitive emissions associated with LNG production have grown strongly in the last two decades as the LNG export industry has expanded.

Figure 9. Fugitive emissions are projected to rise



Note: Projections under the DCCEEW's baseline scenario.
Source: DCCEEW (2022).

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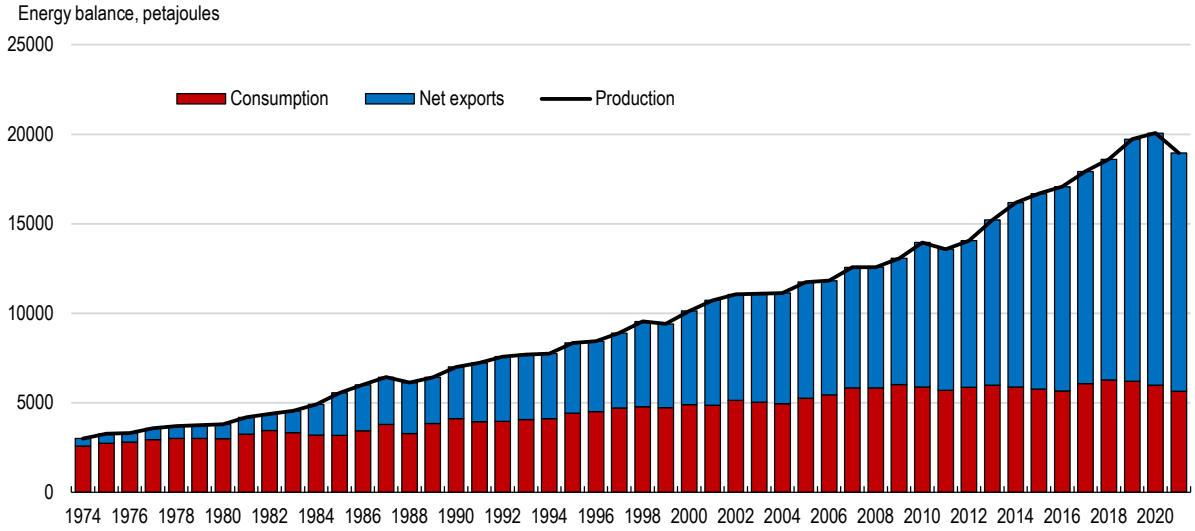
As a major energy exporter, emissions generated in the production of energy exports account for a very significant part of Australian GHG emissions. Energy exports, which are dominated by coal, have more than doubled since 2000, with natural gas exports growing almost tenfold during that period. Total energy production in Australia is currently more than three times higher than the country's energy needs (Figure 10). In particular, domestic coal production is almost 8 times higher than the country's needs, and natural gas production is more than 3 times larger than the country's use of natural gas. Part of the natural gas produced in Australia is consumed domestically in the residential, commercial and industrial sectors, while liquid natural gas (LNG) is exported. As a result, export-oriented sectors were responsible for 41% of Australia's total GHG emissions in 2021 (which does not account for the emissions arising from the use of these exports in destination countries, such as the burning of thermal coal exports). Japan was the main destination of coal exports between 2000 and 2010, when exports to Japan accounted for more than half of Australian coal exports. Since then, China has grown into a major destination of Australian coal exports, accounting for roughly 26% of coal exports in 2020 (coal exports to China dropped significantly in 2021 following trade restrictions). Exports to Korea, India and Chinese Taipei also grew steadily during this period, but exports to Japan remain significant despite a decline in their share of total coal exports. Natural gas exports have also grown rapidly. Japan was virtually the sole destination of natural gas exports between 2000 and 2010, but China's share had grown rapidly to around 41% by 2021. Natural gas exports to Korea and Chinese Taipei have also grown significantly since 2010, but their total share remains small.

Figure 10. Australia is a major energy exporter



Source: DCCEW (2022).

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Emissions from natural gas production are set to become a major driver of emissions in the future, most of which will be driven by export demand as domestic demand for gas diminishes through electrification. Future emissions from natural gas production will therefore depend greatly on transition policies abroad. In 2020, 85% of LNG exports went to countries with net zero commitments (Grattan Institute, 2021b).

Under the IEA's net zero scenario, Australia's fossil fuel exports would shrink dramatically, especially coal exports given that global coal demand would fall by 45% to 2030 and by 90% to 2050, initially driven by declining coal use in the power sector, followed by reductions in coal use in industry (IEA, 2022g). While the government expects coal exports to continue through to 2050, it will be important to develop a roadmap for this sector that takes into account the emissions reduction commitments of Australia's main trading partners and the likely significant fall in demand for coal. Such a roadmap would provide greater clarity for actors in this sector on where to focus efforts and resources.

If this scenario does not materialise, however, significant reductions in emissions intensity will be necessary to meaningfully reduce emissions from this sector, combined with the use of offsets to compensate for unabatable emissions. Emissions intensity in the extractive industries can be improved through the use of renewables, improvements in combustion efficiency, and carbon capture and storage, which will require significant improvements in available technology. The reformed Safeguard Mechanism (explained in Table 2) is Australia's main policy tool to reduce emissions from extractive industries. To comply with the Mechanism, mining facilities will have to reduce their emissions intensity every year in line with their baselines, or purchase Safeguard Mechanism Credits or ACCUs if they exceed them. Additionally, new mining facilities, which could include new mines for critical minerals such as lithium and cobalt, will face stricter baselines than already-existing mining facilities. The recent reforms of the Safeguard Mechanism provide that baselines for these new facilities will be set according to "international best practice levels", which will have to be carefully defined.

Given the abundance of renewable energy resources and a large wealth of critical minerals, Australia has the opportunity to secure the energy transition while remaining a key player in international energy markets. As the global energy system shifts to clean energy, demand for critical minerals is set to hugely increase, quadrupling by 2050 (IEA, 2022). Lithium, nickel, cobalt, manganese and graphite are crucial to battery performance, longevity and energy density (IEA, 2021). Rare earth elements are essential for permanent magnets that are vital for wind turbines and EV motors. Electricity networks need a large amount of copper and aluminium. Australia has particularly large reserves of some of these critical minerals, with 27% of the

world's estimated lithium reserves located in Australia, 22% of the world's nickel reserves, 21% of cobalt, 11% of copper and 10% of manganese ore (Grattan, 2023). Australia is already a dominant producer of some of these minerals: In 2021, it retained its position as the world's top lithium producer (53%) and was also a top five producer for antimony (3%), cobalt (3%), magnesite (3%), manganese ore (11%), rare earths (8%), rutile (26%), tantalum (5%), and zircon (30%) (Hughes et al., 2023).

While critical minerals provide an opportunity for Australia to remain a critical player in energy markets, it will be crucial to ensure that the environmental impacts resulting from their extraction, processing and manufacturing are minimised. Environmental damages can include air pollution, the destruction of habitats such as forests, or pollution of water sources. As part of the Critical Minerals Strategy 2023-30, Australia is working on further developing international standards in this sector, including by participating in technical standard-setting committees and advocacy for internationally aligned critical minerals standards. Work is also underway on a Certification and Life Cycle Analysis for Australian Battery Materials and a Battery Material Provenance Authentication pilot, which will help improve the traceability of minerals provenance. Additionally, the government is also pursuing a reform agenda to strengthen its cultural heritage and environmental protection legislation to ensure that First Nation Peoples can also benefit from the opportunities provided by critical minerals, the deposits of which are often located on land covered by a Native Title claim or determination. In particular, a National Environmental Standard for First Nations Engagement and Participation in Decision-Making is being developed through a co-design process with First Nations peoples.

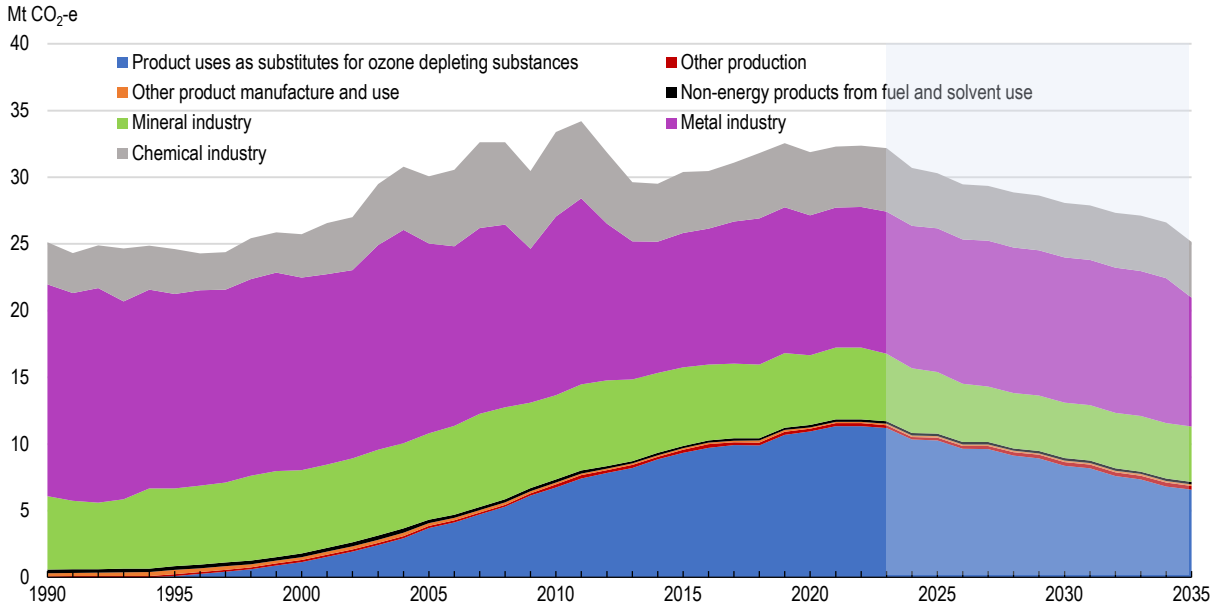
In addition to producing these critical minerals, Australia also has the opportunity to move up the value chain and participate in the production of end-products, such as batteries for EVs and energy storage, and address supply chain bottlenecks in these technologies. While Australia is a major producer of the input materials, most battery manufacturing occurs overseas. The government has recently conducted a consultation to establish a National Battery Strategy to support a competitive battery industry in Australia. The Strategy will build on AUD 100 million in equity funding to deliver a Battery Manufacturing Precinct in partnership with the Queensland government. Further ramping up the production of critical minerals and downstream processing and manufacturing will require streamlining permitting procedures to reduce lead times and increasing government support through grants to early- and mid-stage projects such as the Modern Manufacturing Initiative. Promoting high environmental, social and governance standards (ESG) in this sector will also be crucial to ensure that the production and processing of critical minerals does not result in higher emissions and other environmental damage.

Industrial processes

Australia's manufacturing sector accounts for 8% of value added, with greatest contributions from primary metal and metal product manufacturing, and basic chemical and chemical product manufacturing. Direct emissions from industrial processes arise from process emissions and emissions from combustion. As in other sectors, indirect emissions also arise from the use of electricity in industry. Emissions from industrial processes and product use, which arise from production processes such as iron and steel production, accounted for 6.4% of total net emissions in Australia in 2020, two-thirds of which from the metal, mineral, and chemical industries (Figure 11). Under the DCCEEW's baseline projections, only HFC emissions (refrigerants) are set to significantly decline over the next decade, as a result of the implementation of the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989*, while emissions from metal, mineral and chemical industries are projected to decrease only slightly. Additionally, these projections do not take into account a possible significant increase in mining and processing of critical minerals in Australia, or the production of batteries, which would entail a ramp-up in emissions from these sources unless technologies are developed and implemented to significantly limit these emissions, which is unlikely in the near term.

Figure 11. Emissions from industrial processes will remain high

Industrial processes and product use emissions in the baseline scenario, 1990 to 2035, Mt CO2-e



Note: Projections under the DCCEEW's baseline scenario.
Source: DCCEEW (2022).

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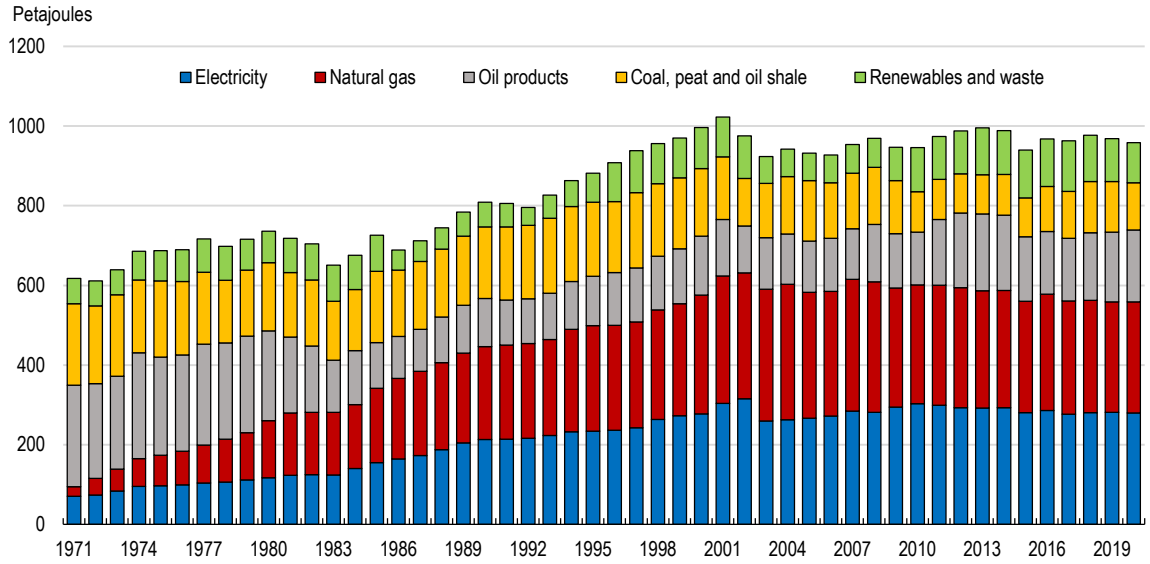
The industrial sector is also responsible for emissions from the generation of the energy it uses, either directly by fuel combustion (or stationary energy) or indirectly by the use of electricity. Manufacturing was responsible for 29 Mt CO_2-e in stationary energy emissions in 2020, most of which are related to the manufacture of non-ferrous metals such as alumina, and chemicals manufacturing. Industry is the sector with the second-highest share of Total Final Consumption of energy in Australia, at 28%, below transport (39%) (IEA World Energy Balances 2022). While there was growing electrification in the sector between 1970 and 2000, the share of electricity in energy consumption has remained broadly constant since then. In 2020, the main sources of energy in industry were electricity (29%) and natural gas (29%), followed by oil (19%), coal (12%), and bioenergy and waste (11%) (Figure 12). Combined emissions from manufacturing peaked in 2008 and were 17% below 1990 levels in 2020. They are projected to fall further by 25% between 2020 and 2030, largely driven by lower indirect emissions from electricity use, but also lower direct emissions from the take-up of cleaner fuels and technologies.

While large facilities in the industrial processes industry will be covered by the Safeguard Mechanism, there are many smaller facilities in Australia that together are responsible for about 30 Mt CO_2-e in emissions, most of which arising from fuel combustion and production processes (Grattan Institute, 2021b). Emissions from these smaller facilities are currently unregulated and will have to fall to contribute to the national emissions reduction goals. Existing energy efficiency certificates, such as the New South Wales Energy Savings Scheme, have seen little take up from industry (IPART, 2021). This is in part due to the fact that plant-specific efficiency measures are difficult to standardise and compare across facilities (as opposed to household efficiency measures based on replacing standard equipment, for example). Energy savings schemes in industry could therefore focus on energy savings from common industrial equipment (Grattan Institute, 2021b). Existing state energy savings schemes could be expanded along these lines, or a new federal energy savings scheme could be introduced.

Figure 12. Electricity and natural gas dominate energy consumption in industry

Total Final Consumption of Energy in Industry by source (PJ)



Source: IEA World Energy Balances 2022 database.

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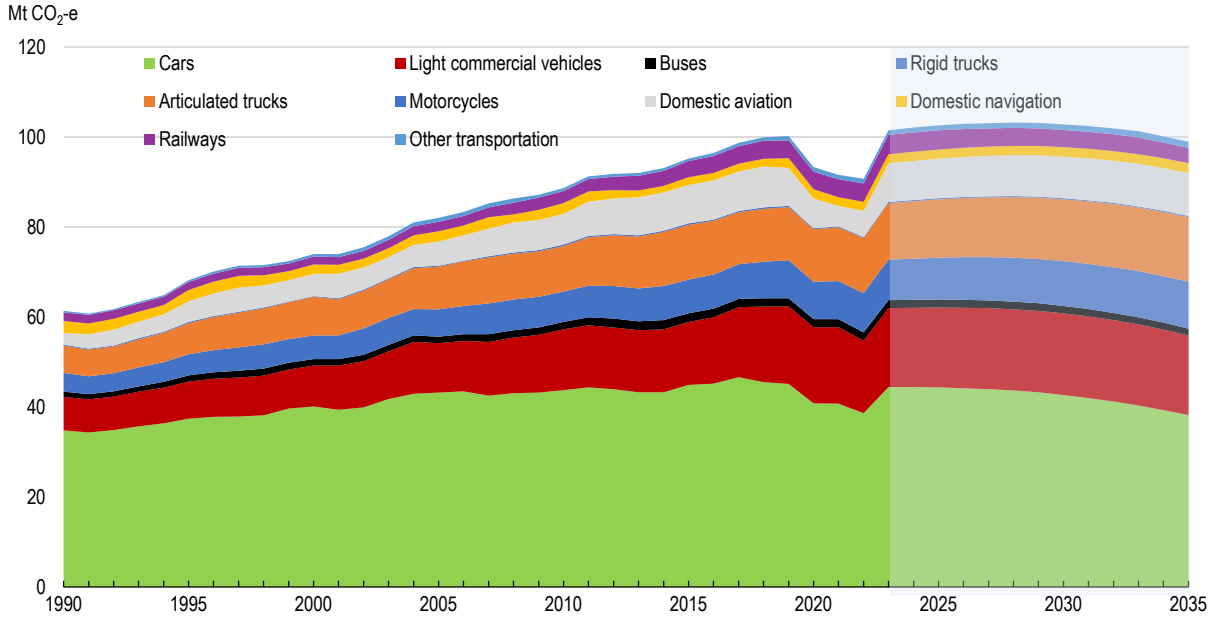
Transport

The transport sector is responsible for roughly 19% of total net GHG emissions in Australia, mostly arising from the combustion of oil products (mostly diesel and gasoline). Road transport plays a large role, accounting for 85% of transport emissions. Light duty vehicles, which include passenger cars and light commercial vehicles such as vans, accounted for 62% of transport emissions in 2020, with freight transport accounting for a further 28%, and domestic aviation accounting for 6% (Figure 13). Transport emissions are projected by the DCCEEW to recover from the pandemic, grow in line with population, and start declining around 2027 as the uptake of electric and hybrid vehicles increases. By 2035, transport is projected to become the largest source of emissions in Australia under current policies. To date, fossil fuels account for more than 95% of total final consumption of energy in transport, with electricity accounting for just 1.7% of consumption, up from 1.1% in 2005 (IEA, 2023). Electricity is currently used mainly in rail transport (where it accounts for 20% of energy demand), whereas the electricity share in road transport is still very small at 0.008% despite a tenfold increase since 2013. Natural gas accounts for 1.5% of energy consumption in the sector, and biofuels account for another 0.3%.

The average fuel efficiency of passenger cars is very low in Australia compared with many other OECD countries (Figure 14 Panels A and B), partly due to the prevalence of large cars such as utility vehicles and SUVs. With road transport accounting for 85% of transport emissions in Australia, significantly increasing vehicle fuel efficiency and a quick transition to electric vehicles (EVs) will be necessary to materially reduce transport emissions. The number of EVs has risen strongly in recent years (EV sales tripled from 2020 to 2021), but EV market penetration in Australia still lags other large western countries. The total EV fleet was close to 50,000 in 2021 (Figure 14 Panel C), compared to Australia's almost 20 million vehicles, of which 15 million are passenger cars and 3.5 million light commercial vehicles. EV sales were 3.8% of total car sales in 2022, below the IEA average of 9% (IEA, 2023; Federal Chamber of Automotive Industries, 2023). EV charging points have also risen in number in recent years, reaching more than 3000 in 2021.

Figure 13. Transport is projected to be the largest source of emissions in Australia by 2035

Transport emissions by source, Mt CO_2-e



Note: Projections under the DCCEEW's baseline scenario.
Source: DCCEEW (2022).

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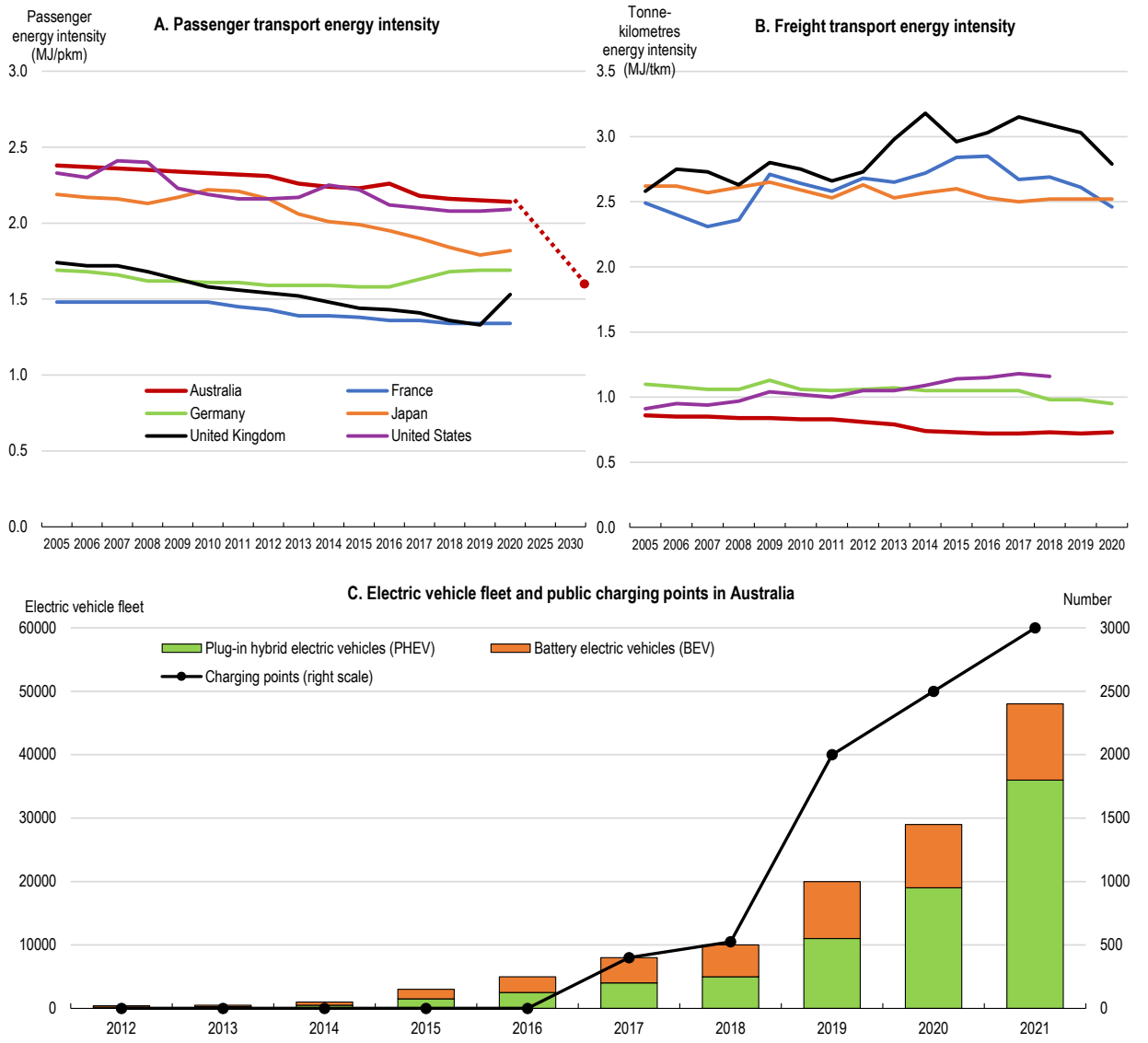
The federal and state governments have put in place a number of policies to incentivise the up-take of EVs. Several states have set electric vehicle targets, either on the proportion of EV sales by a specified date or on government fleets. Some of these states have also introduced policies to incentivise EV purchases, including rebates, stamp duty exemptions, and free registrations, among other policies (see details on these state targets and policies in Table 3). Under the Powering Australia plan, the federal government has introduced a government fleet target to ensure its fleet purchases and leases will be 75% electric by 2025. It has also provided AUD 500 million over 6 years for the Driving the Nation Fund, to fund EV charging infrastructure and hydrogen highways, and passed the Electric Car Discount Bill, exempting eligible electric cars from fringe benefits tax (FBT) and the 5% import tariff. Finally, the federal government is developing a National Electric Vehicle Strategy to scale up efforts to increase demand and supply of EVs by 2030, including by considering the introduction of a federal fuel economy standard.

Figure 14. The energy intensity of Australian vehicles needs to come down significantly to achieve climate targets



Note: The dashed red line illustrates the reduction needed to achieve global net zero emissions target. BEV = battery electric vehicles; PHEV = plug-in hybrid electric vehicles. Charging points include fast and slow chargers.
Source: IEA (2022).

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Table 3. Australia's electric vehicle targets by state

State	Strategy	% of electric vehicles in vehicle sales (2022)	Electric vehicle targets	Incentives	COP26 declaration pledge
New South Wales	NSW Electric Vehicle Strategy (2021)	3.7%	52% of sales will be electric vehicles (EVs) by 2030-31	AUD 3 000 rebates for first 25 000 EVs purchased for less than AUD 68 750 Stamp duty exemptions for EVs purchased for under AUD 78 000	Yes
Australian Capital Territory	Parliamentary and Governing Agreement 2020	9.5%	No official target but going toward all new sales are zero emissions by 2030	Free vehicle registration for two years Stamp duty exemption AUD 15 000 interest-free loan	Yes
Tasmania	No strategy	3.3%	100% EV fleet by 2030 for the government	Stamp duty exemption for EVs for the next two years Free registration for car rental companies and coach operators for two years	No
Victoria	Zero Emissions Vehicle Roadmap	3.4%	50% of sales will be EVs by 2030	AUD 3 000 rebates for first 4 000 EVs purchased for less than AUD 68 740 Incentive amount for 20 000 additional EVs remains to be determined	Yes
Queensland	Queensland's Zero Emissions Vehicle Strategy and Action Plan 2022-2032	3.3%	50% of sales will be EVs by 2030 and 100% by 2036	AUD 3 000 incentive for 15 000 cars under AUD 58 000 EVs are registered in the lowest fee segment (min. saving approximately AUD 70)	No
Western Australia	Electric Vehicle Strategy	2.8%	No target	EVs are exempt from the On-demand Passenger Transport Levy	No
South Australia	Electric Vehicle Action Plan	2.3%	50% of sales will be EVs by 2030 100% of sales will be EVs by 2035	AUD 3 000 subsidies for 7 000 new battery electric vehicle sales under AUD 68 750 Three-year registration fee exemption for new BEVs until 1 July 2025	Yes
Northern Territory	The Northern Territory Electric Vehicle and Implementation Plan 2021-2026	0.8%	No target	Free registration for five years from 2022 AUD 1 500 stamp duty reduction for five years from 2022	No

Source: Electric Vehicle Council (2022), State of EVs 2022.

Demand subsidies can be effective in increasing demand for EVs, but they can come at a high fiscal cost and impose a high implicit carbon price, especially while the decarbonisation of the electricity grid is still ongoing (Productivity Commission, 2023). While fuel taxes can be more efficient (for example, they impose a price on marginal miles driven), fuel economy standards appear to be more acceptable to the public in many countries (Anderson et al, 2011). Aligning the various uncoordinated state subsidy programmes and introducing stringent federal fuel economy standards, which Australia is currently considering, would provide strong incentives to reduce emissions in personal transport at a lower implicit carbon cost. Stringent fuel economy standards would also increase the supply of EVs in Australia, which appears to have limited EV take-up according to widespread reports of extended waiting times for EVs (Productivity Commission, 2023). A relaxation of import restrictions on low- and zero-emissions vehicles would also be desirable to increase the potential supply. While the government is currently considering fuel economy standards for light vehicles, it should also consider introducing standards for trucks and other heavy vehicles, which are responsible for more than 4% of total GHG emissions in Australia.

Existing fuel tax credits are expensive and limit incentives to reduce fuel use. On-road heavy vehicles are currently eligible for a reduced fuel tax in Australia, and businesses pay no fuel tax on fuels used for off-road vehicles, such as trucks in mining sites or for heavy machinery, industrial heating and cooling. These fuel tax credits and exemptions currently cost the government AUD 8 billion per year in lost fuel tax revenues (Terrill, 2023). Fuel taxes for on-road heavy vehicles should be brought in line with fuel taxes on other on-road vehicles such as cars and vans, and the government should consider reducing the generosity of fuel tax credits for off-road vehicles and machinery.

While EV charging needs are currently mostly met by home charging, further increasing demand for EVs will require drastically increasing the number of public charging points. As part of the Driving the Nation Fund, the government will provide AUD 40 million to deliver 117 EV chargers on key highway routes and AUD 130 million to co-fund other charging initiatives through the Australian Renewable Energy Agency. While this additional public funding for charging infrastructure is welcome, further measures will be needed. Despite the low number of EVs currently owned by Australians, Australia has among the lowest amount of charging points per EV compared to other countries covered in the IEA's Global EV Outlook (IEA 2023b). Given the importance of home charging, the National Construction Code could also be updated to require all new buildings to be pre-wired so that they are ready for charging EVs.

The shift to EVs could have revenue consequences for the federal government. As of July 2023, motorists with internal combustion engine (ICE) cars pay 47.7 cents in fuel excise per litre of petroleum, which amounted to AUD 18.3 billion in public revenue in 2021-22 (3.1% of total 2021-22 Budget revenue). As vehicles become more fuel efficient and the take-up of EVs rises, revenues from the fuel excise will fall significantly. Road user charges could provide an alternative source of public revenues and could be charged on EVs and ICE vehicles alike. While such road user charges would somewhat blunt the incentives to purchase EVs over ICE vehicles, they would provide revenues towards maintaining road safety and maintenance and well-funded transport systems. Road user charges could be defined as a function of distance travelled, which similarly to the fuel excise would discourage travelling by road for longer distances, which even with a 100% EV fleet would increase demand for energy. The state of Victoria was the first state to introduce a distance-based road user charge for EVs in 2021, which the High Court ruled unconstitutional in October 2023, arguing that states do not have the power to impose excise taxes on consumption.

While important, electrification and fuel efficiency improvements in vehicles will be insufficient to meet Australia's emission reduction targets. Widespread adoption of sustainable modes of transport, a shift from car dependency, and travel reductions can also contribute to reduce transport emissions. Investing in public transportation can encourage its adoption and reduce the use of greenhouse gas-emitting cars. However, public transport is generally a realistic alternative to cars only in compact urban areas with a high density of infrastructure services and shorter trip distances. Therefore, land use management and

regulations can be an important tool to reduce transportation emissions by encouraging higher population density and building near public sector routes, avoiding urban sprawl.

Agriculture

Climate change is a significant challenge for agriculture, particularly in Australia. Australian farms are vulnerable to the effects of climate change, and they are already facing a greater frequency of extreme weather events and higher volatility in rainfall and temperatures. Agriculture is also a sector where it is technically difficult to achieve large reductions in emissions through abatement In particular, methane emissions from livestock, which are high in Australia given its extensive production of beef and sheep meat, are especially hard to eliminate.

Australia has included the agricultural sector in its economy-wide emissions targets, as opposed to many other countries who exclude agriculture on the grounds that abatement in the sector is too challenging. The inclusion of agricultural emissions is welcome. Australia, however, does not have a specific emissions reduction target for the agriculture sector, unlike many other OECD countries including France, Germany, Denmark, Portugal, Belgium, the United Kingdom, Japan, Korea and New Zealand (OECD, 2022). Such a target can be helpful to focus mitigation efforts, measure progress and send an important signal to the industry. The upcoming sectoral decarbonisation plan announced in July 2023 will provide an opportunity to send such a signal. Australia also joined the Global Methane Pledge in October 2022, a voluntary commitment by 123 countries to collectively reduce global methane emissions across all sectors by at least 30% below 2020 levels by 2030. While this is a welcome signal, this pledge is non-binding and achieving Australia's contribution will require strong policies and planning.

The agriculture sector was directly responsible for 72.6 Mt CO2-e of GHG emissions in 2020, or 14.7% of total Australian GHG emissions. More than two-thirds of these direct emissions from agriculture are due to enteric fermentation (OECD, 2022), a digestive process of cattle, sheep, goats and other ruminant livestock which generates methane. Australia's large beef grazing industry is primarily responsible for emissions from enteric fermentation, with another sizeable contribution from sheep. Agricultural soils, a principal driver of nitrous oxide emissions, are another major source of agricultural emissions, accounting for 18% of direct emissions from agriculture in Australia, while manure management accounted for 9%. Fuel combustion in agriculture, used for transportation/traction, power, and heating, is responsible for an additional 5.6 Mt CO2-e of GHG emissions, 99% of which arise from the combustion of oil (mostly diesel), and 1% from natural gas (IEA, 2022). In addition to these direct GHG emissions, agriculture is also indirectly responsible for the emissions arising from the generation of the energy used in the sector, which accounts for 7% of total final consumption of energy (IEA, 2023).

Given the preponderance of methane emissions from livestock, total emissions from agriculture are closely linked to livestock numbers. Methane emissions from enteric fermentation have fallen substantially from 64.3 Mt CO2-e in 1990 to 51.8 Mt CO2-e in 2020. Recently, declines in cattle numbers due to drought conditions drove a fall in GHG emissions between 2017 and 2020 (Figure 15). However, cattle numbers have started to recover and emissions from agriculture are projected to remain broadly constant until 2030 under current policies (DCCEEW, 2022b).

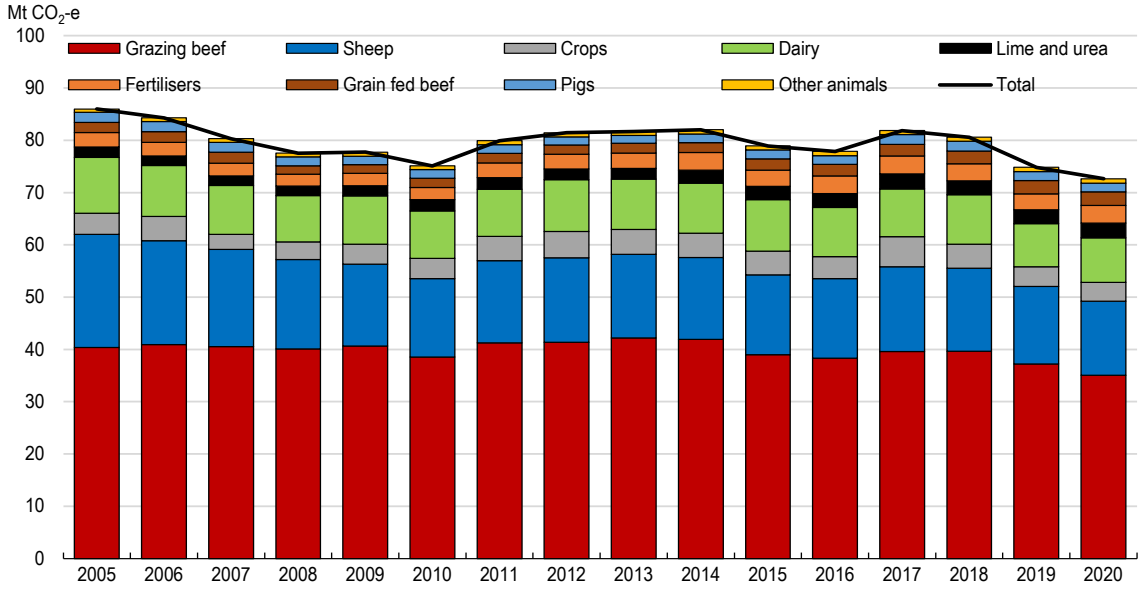
It is especially challenging to tax emissions or establish emissions trading schemes in the agriculture sector, in particular given the difficulty of measuring emissions that do not arise from fossil fuel use, such as methane emissions from livestock. For this reason, countries have excluded agriculture from existing carbon taxing or emissions trading schemes (OECD, 2022), although New Zealand has been considering the introduction of emissions pricing in the sector. Australia is among a small number of countries with a voluntary scheme to issue carbon credits for emissions reduction and carbon sequestration projects in agriculture, through the ACCU Scheme. Japan also introduced a similar scheme in 2013 to provide certified carbon credits for emissions reductions and carbon sequestration activities. In Korea, while agriculture is

not covered by the Korean Emissions Trading Scheme, farmers can obtain certified offset credits for emissions reduction projects and sell these in the emissions trading market.

Reducing GHG emissions in agriculture will require investment in emissions-reducing technologies and their deployment, outreach programs to advise farmers on best practices to practically reduce farm emissions, and the expansion of carbon-offsetting projects in farming. Existing emissions-reducing technologies and abatement practices include improving soil carbon, changing grazing practices, using livestock feed to reduce methane, and changing nitrogen application in cropping systems. In many cases, abatement practices can provide benefits to farmers, including by raising productivity and competitiveness and improving climate resilience (McDonald et al., 2021). In other cases, however, abatement practices can be costly and affect profitability. Reducing these costs and barriers to abatement will be crucial to reduce agricultural emissions.

Figure 15. Agricultural emissions are largely driven by livestock methane emissions

GHG emissions from Agriculture by source, Mt CO_2-e



Source: DCCEW (2022).

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Properly designed public support for agriculture can help reduce emissions in the sector. Overall public fiscal support to agriculture is low in Australia (Box 4) and is characterised by a strong emphasis on market openness, building climate resilience, and investments in public goods, including R&D, hydrological infrastructure and biosecurity (OECD, 2022). Agricultural producer support in Australia focuses on disaster relief payments, income support and income-smoothing programmes such as the Farm Management Deposits and income tax averaging arrangements. Australia has an extensive agricultural knowledge and innovation system, with approximately one-quarter of total public expenditure for agriculture directed to support for R&D, innovation and extension services (compared with just 6% in the OECD). Notable examples of such support include the Future Drought Fund, established in 2020, which invests AUD 5 billion in drought resilience initiatives, including developing better farming and land management practices that improve drought resilience and helping farmers plan for droughts. More recently, the government announced the commitment of up to AUD 3 billion from the AUD 15 billion National Reconstruction Fund to support investment in low emissions technologies and component manufacturing and agricultural methane reduction. The Government has also committed AUD 8 million for the seaweed industry to support commercialisation of the low-emissions livestock feed supplement called Asparagopsis. The second and third stages of the Methane Emissions Reduction in Livestock (MERiL) Program will provide a total of AUD

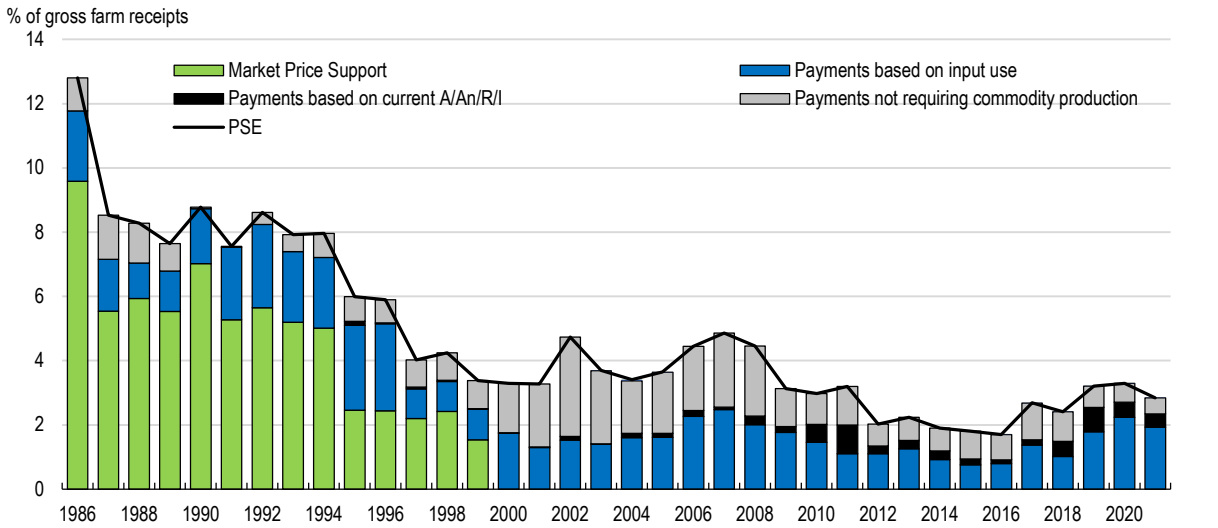
20 million in funding to develop technologies to deliver low emission feed supplements to grazing animals and determine their technical viability and commercial potential.

Given its current low level, there is scope to further increase support to agriculture through policies that encourage further emissions reduction in the sector, including support for agricultural R&D and innovation but also extension services and agricultural education which receive smaller amounts of funding. Support for technology should focus on areas with the highest potential impact on agricultural emissions, such as reducing the emissions intensity of livestock and electrifying farming machinery. Other policies that could provide additional support to agricultural producers include concessional loans for investments to reduce emissions, such as electric or hydrogen-powered machinery which have with high upfront costs, or income-contingent loans where required repayments depend on project revenue (Grattan, 2021).

Box 4. Support to agriculture in Australia

Australia's financial support to agricultural producers is among the lowest in the OECD, estimated at 3.1% of gross farm receipts for 2019-21, with total support to agriculture representing 0.2% of GDP (OECD, 2022). More than half of support to producers in 2019-21 was input subsidies. Much of these went to on-farm investments, including in response to adverse events. The bulk of remaining producer support went to disaster relief payments, income support, and income-smoothing programmes that address cash flow fluctuations, such as the Farm Management Deposits and income tax averaging arrangements.

Figure 16. Composition of the Australia's agriculture producer support estimate



Notes: A/An/R/I: Area planted/Animal numbers/Receipts/Income
Source: OECD Producer and Consumer Support Estimates, OECD Agriculture Statistics

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During 2019-21, the general services support estimate (GSSE) averaged 2.6% of the value of agricultural production, substantially higher than in the late-1980s (0.7%) and early 2000s (1.9%), but below the OECD average. Australia has an extensive agricultural knowledge and innovation system, with approximately one-quarter of total public expenditure for agriculture directed to support for R&D, innovation and extension services (compared with just 6% in the OECD). Public expenditure on biosecurity inspection and control services, and to develop and upgrade infrastructure (mostly hydrological) represents the bulk of the remaining expenditure on general services.

Research and development are a major component of general services for the sector, while extension services and agricultural education receive smaller funding. The Future Drought Fund and the National Agricultural Innovation Agenda encompass innovation generation and adoption.

Source: OECD (2022).

Through the ACCU Scheme, which was established in 2015, farmers and landholders can earn Australian Carbon Credit Units (ACCUs) by implementing projects that reduce or avoid the release of GHG emissions or remove and sequester carbon from the atmosphere. To date, agricultural projects account for only 1.65% of ACCU issuance, not including vegetation projects which are often undertaken on agricultural land. Policies that cap net emissions in other sectors, such as the Safeguard Mechanism for the industrial sector, could raise demand for ACCUs, which will result in a higher value and could incentivise more farmers to invest in carbon credit generation. In the absence of strong demand for ACCUs from other sectors, efforts to scale up the ACCU Scheme, which so far has had a limited impact on agricultural emissions, could strengthen progress on emissions abatement in the agriculture sector.

The Climate Change Authority conducted a review of the ACCU Scheme in 2020, which highlighted several recommendations for the government's consideration, including allowing for a broader set of methods to be eligible under the Scheme. In this regard, the government established a new process for stakeholders to propose new emission reduction activities and provide evidence and information to support the potential development of a new method. Given the low take-up in the agricultural sector, special consideration should be given to adding new agricultural methods that could be eligible under the ACCU Scheme. The Scheme currently accepts 7 agricultural methods (Box 5). Ensuring that the process to consider new emissions reduction methods in agriculture is effective, robust and expeditious while ensuring the integrity and additionality (ensuring that the credited abatement would not have happened under a business-as-usual scenario) of the newly eligible projects will be key. The administrative costs of submitting projects under the Scheme can be high, especially for relatively smaller businesses. Given that more than 80% of farming businesses are relatively small operations receiving less than AUD1 million in revenues (Grattan, 2021), streamlining administrative processes and reducing transaction costs, while ensuring the integrity of the scheme, could spur greater participation in the Scheme. Capacity building programmes such as the Carbon Farming Outreach Program that provide direct support to potential scheme participants are welcome, particularly for rural and remote communities, including First Nation Australians.

Data collection practices to track emissions from agriculture could be improved to better account for agricultural emissions in national emissions reporting and to assess the impact of emissions reduction policies and technology take-up in the sector. For example, auditing may be necessary to assess the impact of the use of feed supplements on emissions (Grattan Institute, 2021). Farm-level data will also be required if a low-emissions certification scheme is introduced.

Overall, while policies discussed in this section can all contribute to reducing emissions in agriculture, it will be difficult to reach net zero emissions in this sector while maintaining current livestock herd sizes, barring significant advances in emissions-reducing technologies such as low-emissions livestock feed supplements. This raises the question of whether, in the absence of emissions pricing in agriculture, policies should be considered to limit herd sizes or incentivise their reduction and the diversification of production towards other commodities. A number of OECD countries, including Ireland, are currently considering policies to encourage farmers to reduce the average age of slaughter.

Box 5. Agricultural methods eligible under the ACCU Scheme

List of available agricultural methods

To be eligible under the ACCU Scheme and receive Australian Carbon Credit Units, emissions reduction projects in agriculture must follow one of the following finalised methods:

- Animal effluent management method
- Beef cattle herd management method
- Estimating sequestration of carbon in soil using default values method
- Estimation of soil organic carbon sequestration using measurement and models method
- Fertiliser use efficiency in irrigated cotton method
- Reducing GHG emissions in beef cattle through feeding nitrate containing supplements method
- Reducing GHG emissions in milking cows through feeding dietary additives method

Expanding the list of available methods

The list of finalised methods can be expanded under a process involving the Minister for Climate Change and Energy, the Clean Energy Regulator, the Emissions Reduction Assurance Committee, the Department for Climate Change, Energy, the Environment and Water, and consultation with industry, potential end-users and experts.

The Minister decides which activities to prioritise for new carbon crediting method development based on these criteria:

- the potential uptake of the method and the likely volume of reduced emissions
- whether the volume of emissions reduced can be estimated at an acceptable cost and to a reasonable degree of certainty
- whether it could have an adverse impact on society, the environment or the economy
- whether it could be better supported by other government measures
- alignment with broader government priorities

The method prioritisation process is currently under review following the outcomes of the ACCU Review, which proposed a proponent-led method development process.

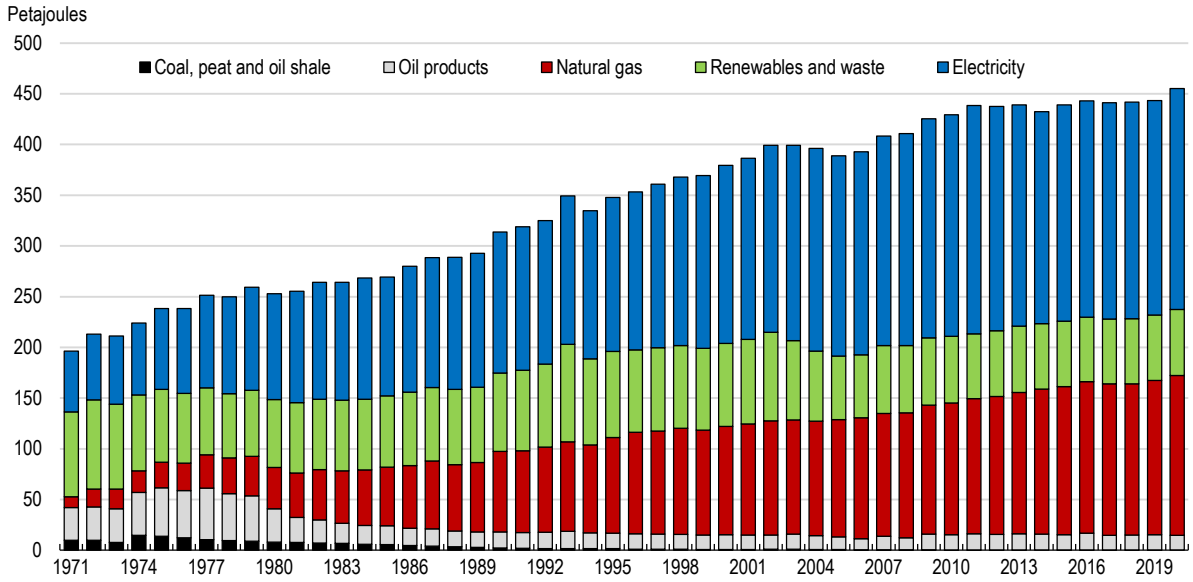
Source: DCCEEW.

Buildings

Buildings directly and indirectly produce GHG emissions from fuel combustion (stationary energy) and electricity use. Buildings account for more than 23% of energy demand in Australia. Residential buildings were responsible for 61% of total energy demand from buildings in 2020, with the remainder of energy demand coming from buildings in the service sector (IEA, 2023). Energy demand from the residential sector grew significantly since the 1970s before plateauing around 2010 (Figure 17). In 2020, 48% of energy demand from residential buildings was covered by electricity, followed by natural gas (35%), bioenergy and waste (14%), and oil (3%). The dwelling stock in Australia currently stands at almost 11 million dwellings, 71% of which are houses, 16% apartments, and 13% are townhouses (semi-detached, row or terrace houses).

Figure 17. The residential sector needs to be further electrified

Total Final Consumption of Energy in the Residential sector by source (PJ)



Source: IEA World Energy Balances 2022 database.

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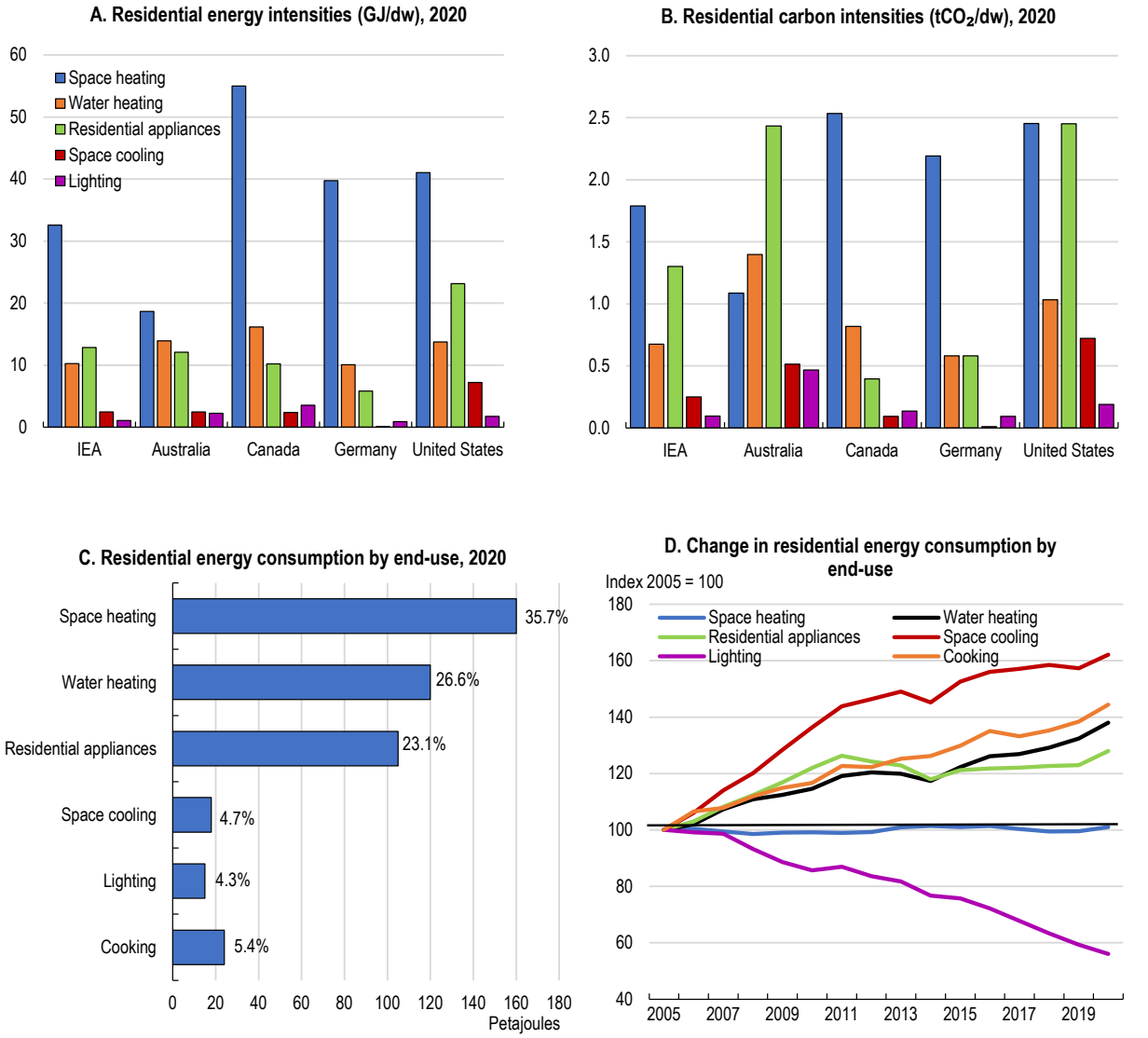
Emissions from fuel combustion amounted to 11 Mt CO_2−e in residential buildings in 2020, and 6 Mt CO_2−e in commercial buildings. These combined emissions are projected by the DCCEEW to remain broadly constant until 2030 under existing policies, before falling to 14 Mt CO_2−e by 2035 as existing buildings are electrified and newer more electrified buildings are built. To further reduce building emissions, further electrification (coupled with decarbonising electricity generation) and strong improvements in energy efficiency will be required. The IEA estimates that a 5% improvement in residential energy efficiency per year will be required to reach net zero under the IEA Net Zero Roadmap (IEA 2021, 2022b), which is significantly higher than the energy efficiency gains in recent years (less than 1% per year on average between 2015 and 2020).

According to the IEA's Energy Efficiency Indicators database, space heating (36%) is the largest source of energy consumption in Australian residential buildings, followed by water heating (27%), appliances (23%), and cooking, lighting and cooling (around 5% each) (Figure 18, Panel C). Space heating is mainly fuelled by natural gas (58%), followed by bioenergy (29%) and electricity (12%). While cooling has been a relatively smaller source of energy use in residential buildings, it has grown significantly in recent years (by almost 70% since 2005) and has become a major contributor to peak electricity demand and a driver for investment in electricity generation and network capacity (Figure 18, Panel D). Residential energy intensities in Australia are comparable to the IEA average and those of Canada, Germany or the United States, except for the exceptionally low energy intensity in space heating. However, after accounting for fuel use and the electricity generation mix, the resulting residential carbon intensities are relatively high in Australia, especially in water heating and residential appliances.

Figure 18. Residential energy consumption by end-use



Source: IEA Energy Efficiency Indicators database.

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While pricing carbon is an efficient way to internalise climate externalities and spur innovation, the buildings sector is not as responsive to price signals as other sectors, in part due to long renovation cycles (Hoeller et al., 2023; D'Arcangelo et al., 2022). Net effective carbon rates on buildings are close to zero in Australia, and only a few countries have achieved net effective carbon rates above EUR 60 per tonne of CO_2, a mid-range estimate of current carbon costs (OECD, 2021b). Standards and regulations can also help overcome market failures in the building sector. However, they are not cost-minimising and can increase the cost of decarbonisation by blurring price signals and blunting economy-wide incentives (D'Arcangelo et al., 2022).

Given the long average lifespan of new homes, design, and construction decisions such as heating systems, building material, and housing size and type are crucial for the decarbonisation of the housing stock. Updated building energy codes accompanied by the relaxation of regulatory deterrents to new housing can ensure that the housing stock becomes progressively more energy efficient. Land-use policies that limit development in inner and middle-ring suburbs (Coates and Moloney, 2023) should also be reviewed given that they also play an important role in reducing urban sprawl, which has direct as well as indirect environmental implications. Australia's growing population will require an expansion in the housing

stock, and ensuring that the new buildings are as energy efficient as possible will be crucial. However, it will also be important to increase the energy efficiency of existing buildings, through retrofitting, better isolation, and the installation of more efficient appliances,

Further increasing the energy efficiency of residential buildings will be important in helping Australia meet the economy-wide emission targets. There have been significant improvements in the energy efficiency of commercial buildings in recent years, in part due to disclosure and labelling mandates (IEA, 2023; Lee, Gumulya and Bangura, 2022). However, energy efficiency gains in residential buildings have stalled. To address this, the authorities have outlined the *Trajectory for Low Energy Buildings* strategy, which will consider a range of policies, including mandatory disclosure of energy performance, minimum energy efficiency standards for rental properties, improving heating, ventilation, and cooling systems, and appliance standards and labelling. It will also consider specific measures for vulnerable households to overcome barriers to adopt energy productivity measures and services.

A recent change to the National Construction Code will increase the minimum energy performance standards for new residential buildings, which will be mandatory by October 2023, and work has begun on the following triennial update to the Code, which will focus on commercial buildings. Minimum energy performance standards in the building code should continue to be updated periodically. The Nationwide House Energy Rating System (NatHERS) rates the energy performance of newly constructed or renovated homes, including the energy performance of appliances, the use of solar panels, and the efficiency of the building shell. However, the rating and its disclosure are voluntary and does not cover existing housing and rental properties. A disclosure obligation of the NatHERS rating should be implemented, especially for rental properties. Minimum energy efficiency requirements for rental properties could also be considered (for example, France has outlawed the rental of extremely energy-inefficient housing starting in 2025 and plans to outlaw the rental of housing rated F or G according to its energy efficiency rating system starting in 2028). Energy efficiency ratings are required for commercial office space of 1000 square meters or higher, under the National Australian Built Environment Rating System (NABERS). Given the effectiveness of this program, the requirement for ratings could be expanded to other commercial sectors, such as hotels, and especially to high-energy buildings such as data centers.

Retrofitting the existing housing stock (for example by electrifying heating and cooling, improving insulation, and incorporating on-site renewable energy) is a crucial priority to achieve decarbonisation targets in the buildings sector. It is also increasingly relevant in terms of easing energy security concerns and adapting to climate change (IEA, 2022d). Many existing homes were built before energy performance standards were introduced. Covering existing housing under the NatHERS energy efficiency ratings could provide incentives for retrofitting the existing building stock. In its 2023-24 Budget, the government announced it would provide AUD 1.3 billion to the Household Energy Upgrades Fund, which includes AUD1.0 billion of low-cost loans to support energy efficiency upgrades for households and $300 million to support upgrades for social housing in collaboration with states and territories. Several other energy saving schemes currently exist at the state and territory level, providing market mechanisms to incentivise improved energy efficiency. Aligning these schemes and reducing administrative costs would improve their effectiveness. Addressing labour shortages in the construction sector would also be crucial given the size of the retrofitting challenge. To do so, authorities should consider increasing funding for training and upskilling schemes, which is low in Australia compared to other OECD countries (see the following section).

Energy efficiency standards can imply large costs, which can weigh particularly on lower-income households. Regulatory approaches to decarbonisation are generally more regressive than carbon taxes (Fullerton and Muehlegger, 2017; Brucal and McCoy, forthcoming). There is a case for providing bridging loans and subsidies, as the subsequent annual energy savings can be low compared with the cost of renovation. However, subsidies for emissions reductions can bring large benefits to high-income homeowners, as energy-efficiency improvements have been shown to become capitalised in house prices (Reusens, Vastmans and Damen, 2022). Australia could consider targeting subsidies to lower-income households through income-based eligibility criteria and refundable tax credits for energy efficiency

improvements and renovations. The MaPrimeRénov in France, for example, offers higher grants for retrofitting projects performed by lower-income households (up to EUR 10 000 per project) and an advance payment to undertake the renovations for the lowest income households who may struggle to finance the renovations up-front (OECD, 2022c).

Managing the impact of the climate transition

The transition to net zero emissions presents a number of opportunities for the Australian labour force, but also a number of challenges. The renewable energy sector, for example, has the potential to be a major source of jobs in Australia. However, Australia's labour market faces three distinct challenges from the transition to net zero: First, workers in highly emitting industries such as coal mining that face rapid declines in activity will face unemployment or have to re-train or find a job elsewhere. Second, as a result of carbon mitigation policies, employment will have to be reallocated from more carbon-intensive activities towards greener activities. Finally, as businesses adapt their production processes and adopt greener technologies to reduce their GHG emissions, workers who will not lose their jobs will nevertheless have to re-train and upgrade their skills as their occupations become greener (Hummels et al., 2012; Becker, Ekholm and Muendler, 2013). Public policies can help surmount these three challenges by supporting workers facing unemployment due to the transition to net zero, encouraging the reallocation of labour across sectors and regions, identifying and addressing worker shortages and encouraging the re-training of the workforce, thus minimising the costs of the transition.

Workers in carbon-intensive industries may face considerable adjustment costs such as losing their wage income, having to search for a new job, learning new skills, and having to move to other locations given that green jobs may not be created in the same locations (Grundke and Arnold, 2022). For example, renewable power generation facilities have to be placed near the natural resource they exploit, unlike fossil fuel power plants (OECD, 2017b). Prolonged unemployment could also lead older workers to leave the labour force altogether (Hyman, 2018). Carbon-intensive jobs also tend to be geographically concentrated (Box 6), and the climate transition will therefore have outsized impacts on particular regions heavily dependent on these jobs and industries for income, revenue and investment (Morris, Kaufman and Doshi, 2019; Elgouacem et al., 2020). Mass layoffs tend to cause local recessions and have long lasting effects on communities (Hanson, 2023).

As both Australian and global energy consumption shifts away from coal, and as alternatives for metallurgical coal are developed, there will be less demand for Australian coal both domestically and from abroad. While the transition will take long and the government still expects coal exports to continue through to 2050, coal production and employment will have to fall in order to achieve the emissions reduction targets. According to the 2021 Census, there are roughly 50,000 workers in the coal mining industry in Australia, representing slightly more than 0.4% of total employment. These are fewer workers than those employed in the Australian automotive industry at the turn of the century, around 80,000 (Stanford, 2020), before the sector collapsed and all automotive plants were shut down. Other countries have experienced coal transitions involving much larger numbers of coal mining workers. For example, mine closures in the Limburg region of the Netherlands led to a loss of 75,000 coal mining jobs between 1965 and 1990; coal mining jobs declined by 160,000 in the Appalachian and Powder River Basin in the United States between the 1970s and 2015; and the closure and consolidation of mines in Poland resulted in a loss of roughly 230,000 jobs between 1990 and 1999 (Caldecott, Sartor and Spencer; 2017). Today in Australia, coal mining is highly capital intensive with fewer workers required to operate the large machinery used to extract coal deposits. The age structure of the coal mining workforce in Australia also implies that a significant part of the workforce will retire naturally between now and 2030, as around 20% of the current coal mining workforce under 60 years old will be 60 or older in 2030 according to the 2021 Census.

While the absolute number of coal mining jobs in Australia is not very high, coal mining jobs are highly concentrated geographically in regional parts of Queensland and New South Wales, and in Collie in

Western Australia. According to the 2021 Census, there are 10 regions (at the Statistical Areas Level 3) in which coal mining accounts for more than 5% of total employment, and 7 regions where the share of employment is 10% or higher: Bowen Basin North (in Queensland, 21% coal mining employment share), Central Highlands (in Queensland, 20%), Upper Hunter (in New South Wales, 15%), Biloela (in Queensland, 12%), Lithgow-Mudgee (in New South Wales, 11%), Lower Hunter (in New South Wales, 11%) and Mackay (in Queensland, 10%). Together, these 7 regions account for almost half of all coal mining jobs in Australia. These regions that are heavily reliant on coal mining demand specific policy measures to transform their industrial specialisation and enable the geographical relocation of a significant number of workers (D'Arcangelo et al., 2022). Place-based policies combined with policies aiming to remove obstacles to geographical mobility can help with this transformation. Place-based policies include early-stage reskilling and up-skilling, public investment programs, and improvements in social conditions through higher quality healthcare and transport policies in the region (Botta, 2019; Causa, Abendschein and Cavalleri, 2021).

While renewable energy cannot replace all coal mining jobs, it can play a meaningful role in a wider regional industry development plan that creates employment across a range of sectors. Renewable energy will be a major source of jobs in Australia in the medium-term. Employment in this sector is already higher than in the thermal coal mining sector, and it is set to become larger than total employment in all coal mining (thermal and metallurgical) as Australia ramps up renewable capacity to fulfil its renewable electricity targets (Briggs et al., 2020). According to Accenture (2023), the transition to renewable energy will create jobs for almost 200,000 workers by 2050 and will require an additional 60,000 workers before 2030. Renewables will create employment across a wide range of occupations, especially for trades and technicians, labourers and professionals. After the initial construction and installation phase of renewables deployment, the number of jobs in operations and maintenance will increase and is projected to account for more than half of renewable energy jobs by 2030. In terms of occupations, there are a number of overlaps that could make renewable energy a source of alternative employment for coal mining workers. Renewable energy will employ more workers than currently employed in coal mining across a range of occupations, including construction and project managers, engineers, electricians, mechanical trades, office managers and contract administrators and drivers. However, there is no direct correspondence in renewable energy for drillers, miners and shot firers, which are the largest category of coal mining jobs. There is also some overlap between coal mining regions and the Renewable energy zones identified by the government as having the greatest potential for renewable energy (e.g. Isaac and Fitzroy in Queensland; North-West REZ and Central West REZ near the Hunter Valley in New South Wales).

The renewable energy transition will require significant efforts in terms of skilling and training the Australian workforce. Some green jobs require high levels of education, work experience and on-the-job training, and use high levels of cognitive and interpersonal skills (Consoli et al, 2016; Vona et al., 2018; Saussay et al., 2022). According to certain estimates, around half of the workers needed for the renewable energy transition are needed in an occupation currently facing national shortages, such as electricians and engineering professionals (Infrastructure Australia, 2021). Importantly, many of these occupations are high-skilled occupations, requiring formal education and training at TAFE (vocational education) or university. Significantly increasing the number of candidates for these high-skilled occupations will therefore take time, careful planning and investment. Surveying the needs of the energy industry will help anticipate the needs for workers and guide the structural adaptation of the education system.

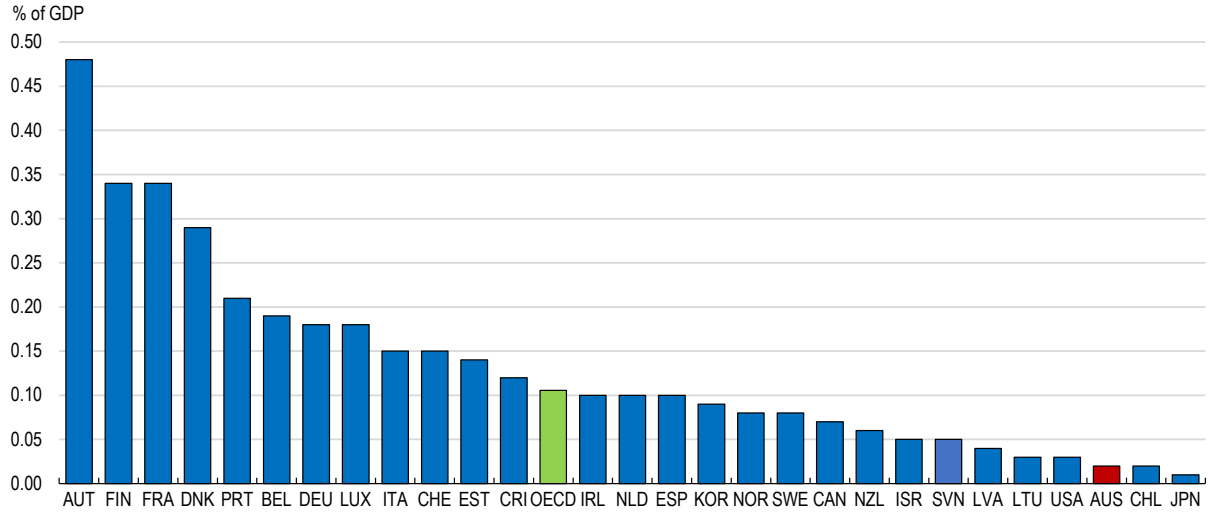
Part of the shortage of renewable energy workers could be addressed by increasing the representation of women in these occupations. For example, women accounted for just 2.1% of the electrician workforce and 13.1% of the engineering workforce according to the 2021 Census. Many occupations with very low participation by women are currently facing national worker shortages, including electricians, engineers, mechanical engineering trades workers, mobile plant operators, construction and mining labourers and truck drivers. Policies that promote greater enrolment of women in education or vocational training for these occupations are welcome, such as the Growing our Clean Energy Workforce initiative in Victoria

which subsidises 50% of the cost of new apprenticeships to support more women entering the industry and offers free or low-cost training by professional organisations to women currently working in related energy industries.

The federal government has announced a number of policies to address the jobs and skills shortage. It established a AUD 1 billion JobTrainer fund from 2020-22, to offer free or low fee training in priority certifications, with matched contributions from state and territory governments, and committed AUD 105 million to the New Energy Apprenticeships and New Energy Skills programs to deliver 10,000 energy apprentices and tailor skills training to the specific needs of new energy industries. The 2022-23 federal budget included AUD 922 million in funding over the next five years towards 480,000 fee-free TAFE places, and to establish the TAFE Technology Fund to modernise training facilities. The 2023-24 federal budget included funds to establish the Net Zero Authority to support workers in emissions-intensive sectors and to coordinate programs and policies across government supporting regions and communities through the net zero transition. As part of this, Jobs and Skills Australia is currently conducting a capacity study on the workforce needs for the transition to a clean energy economy. Despite these actions, there is still scope to ramp up active labour market programs in Australia. Job-search and training schemes can help reallocate workers from highly-polluting industries and address skill mismatches (D'Arcangelo et al., 2022). Public spending on training programs in Australia amounted to 0.03% of GDP in 2020, compared to the OECD average of 0.11% of GDP (Figure 19).

Figure 19. Spending on training policies is low

Public expenditure on training-related labour market programs (% of GDP), 2021



Source: OECD Labour Market Programmes database.

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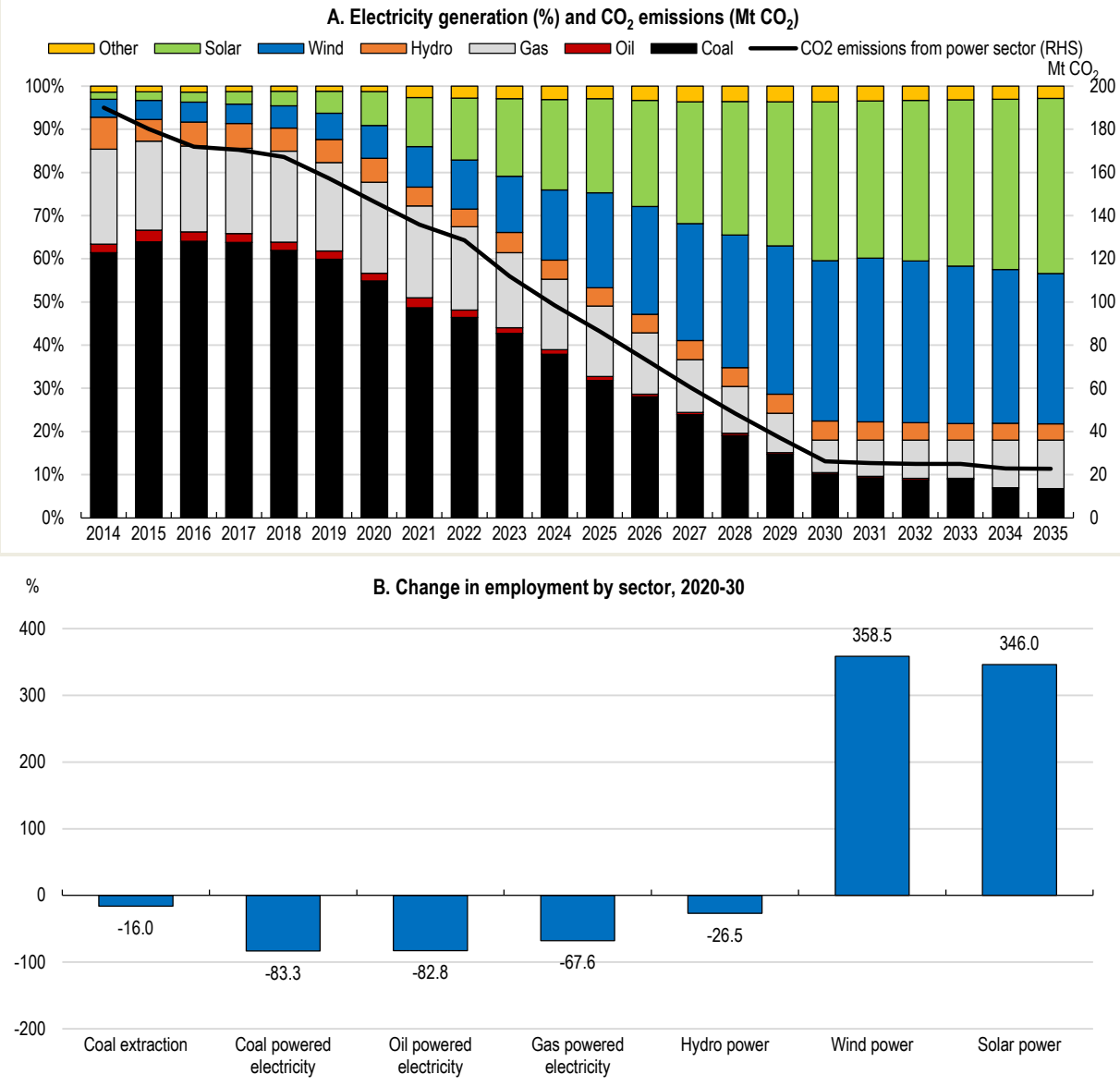
Box 6. Labour market reallocation under the transition to net zero

The OECD ENV-Linkages model, a dynamic global Computational General Equilibrium (CGE) model, is used to illustrate the labour market effects of Australia's current climate policies, including the latest reforms to the Safeguard Mechanism and the 82% renewable electricity target by 2030 (Château, Dellink and Lanzi, 2014). The model was calibrated to match the emissions projections of the Department of Climate Change, Energy, the Environment and Water, in which GHG emissions fall by 31% between 2020 and 2035, a significant reduction but still short of Australia's target to reduce emissions by 43% between 2005 and 2030. The model also assumes that the government's 82% renewable electricity target is met by 2030.

Figure 20. As electricity generation shifts to renewables, employment in renewable energy will soar, while it will fall significantly in coal, oil and gas-powered electricity generation



Note: This model is calibrated to match the DCCEEW's "additional measures" scenario which takes into account current policies, the latest reforms of the Safeguard Mechanism and the 82% renewable electricity target by 2030.
Source: OECD ENV-Linkages model.

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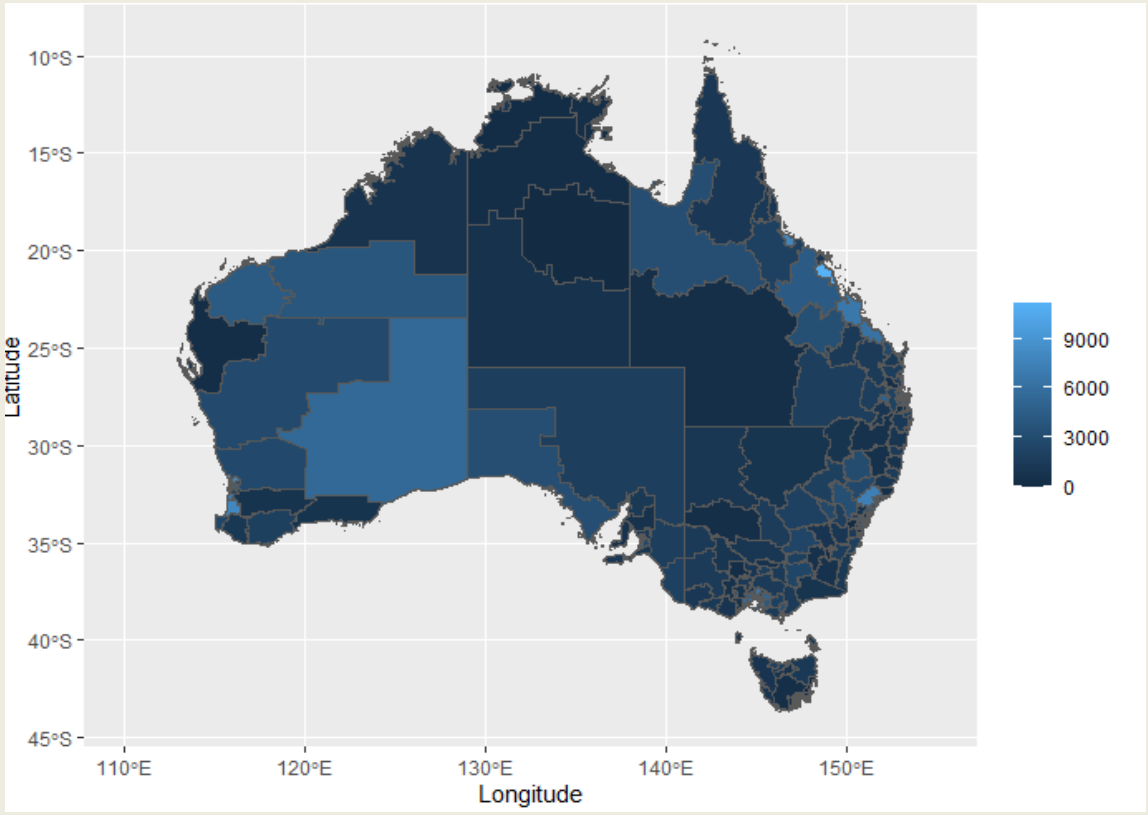
As the power mix dramatically shifts towards renewables, employment in renewable energy is estimated to soar between 2020 and 2030, rising more than three-fold in wind and solar power (Figure 20). On the other hand, employment in coal extraction and coal, oil and gas-powered electricity generation is projected to fall significantly as renewable targets are met.

Data from the 2021 Census, the Labour Account and the Household, Income and Labour Dynamics (HILDA) Survey provide information about workers in highly-polluting "brown industries", defined as the 7 ANZSIC subdivision sectors with the highest emissions per worker (similarly to Causa and Soldani, forthcoming) and including coal mining, oil and gas extraction, petroleum and coal product manufacturing. These jobs are highly concentrated geographically in certain specific regions (Figure 21). These sectors are also highly gender-segregated, with 80% of male employment, compared to 52.3% for the overall economy. Workers in brown industries also tend to be relatively highly paid and more likely to have received technical education. According to the 2021 Census, the average age of coal miners is slightly higher than Australia's labour force, at 42 years compared to 41 years. By 2030, 20% of the current coal mining workforce under 60 years old will be 60 or older.

Figure 21. Employment in brown industries is highly concentrated geographically

Number of employed workers in brown industries, by SA3 region



Note: Brown industries include coal mining, oil and gas extraction, petroleum and coal product manufacturing, non-metallic mineral product manufacturing, primary metal and metal product manufacturing, electricity supply and gas supply.
Source: 2021 Australian Census.

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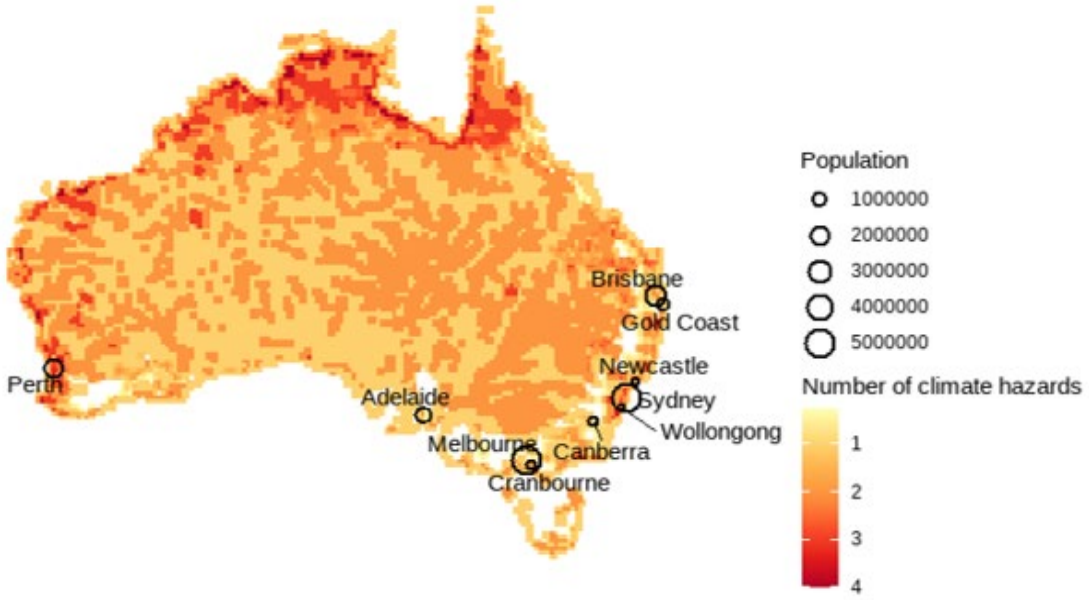
Adapting to climate change

Climate change and higher climate variability increase the risks of climate hazards, affecting the frequency, intensity, extent and duration of extreme weather and climate events (OECD, 2022b; IPCC, 2022; Spinoni, Naumann and Vogt, 2017). This can result in loss of life and property damage and impact biodiversity and ecosystems around the world, with significant economic costs (CRED, 2019).

Australia is particularly exposed to climate-related hazards according to OECD (2022b). Exposure to heat stress and fires is high and rising (Canadell et al., 2021), and droughts have worsened. Australia ranks 2nd and 5th in the world in population and forest exposure to wildfires, 3rd in cropland exposure to drought, and 6th in terms of population exposure to extreme temperatures (OECD Climate-related hazards database). Extreme heat in Australia has already been responsible for more deaths in Australia than any other natural hazard (Productivity Commission, 2023). Heavy rainfall events and tropical cyclones are expected to become more intense (IEA, 2022). Physical capital is also at risk, with Mallon et al. (2019) estimating that the number of properties at high risk from river flooding, coastal inundation, bushfire and wind risk will rise from 383,000 to 736,000 between 2020 and 2100. Importantly, further global warming and related higher climate risks are already "locked in" and will occur regardless of global emissions reductions.

Figure 22. North Australia is especially exposed to climate hazards



Note: The multi-hazard map considers only five climate-related hazards: extreme heat, wildfire, wind threats, coastal flooding and river flooding. Areas exposed to extreme heat experience more than 14 days of very hot days (daily maximum temperature exceeding 35 °C). Wildfire risk refers to regions where the Canadian Fire Weather Index, adjusted for biomass availability, indicates very high or extreme fire danger. Regions exposed to wind threats experience violent storms with a sustained gust speed of at least 28.6 m/s (Beaufort class 11). River and coastal flooding refer to areas that are exposed to flooding with a return period of 100 years.
Source: Maes et al. 2022.

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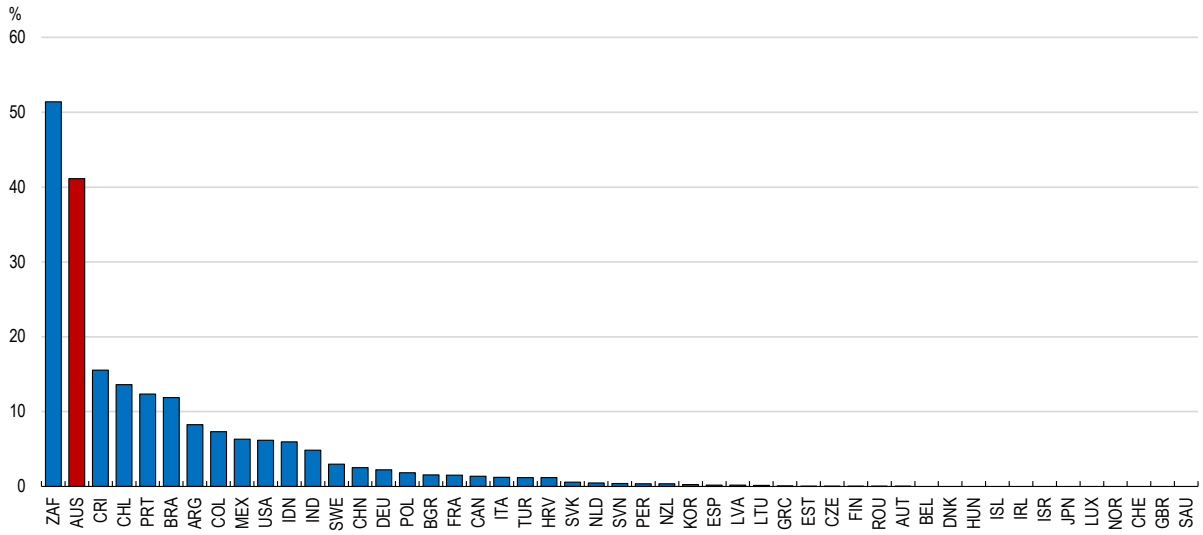
Figure 23. Australia is among the countries with the highest exposure to wildfire risks

Percentage of population exposed to very high or extreme wildfire danger, annual average over 2017-2021



Source: IEA/OECD Climate-related hazards: Wildfire, Environment Statistics database.

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Some of these climate-related hazards are already impacting Australia. Severe bushfires in many parts of the country during the Black Summer of 2019-20 burnt an estimated 24.3 million hectares, destroyed 3,000 buildings, and drove some endangered species into extinction, with economic costs approaching AUD 100 billion (Royal Commission, 2020; Binskin, Bennett and Macintosh, 2020; Slezak, 2020; Daley, 2020). In early 2022, Australia experienced one of the country's most severe flood disasters with a series of floods in the states of Queensland and New South Wales causing hundreds of school closures, evacuations and food shortages. According to Insurance Council of Australia, these floods incurred almost AUD 6 billion in insurance claims as of April 2023.

As set out in Australia's National Climate Resilience and Adaptation Strategy 2021-2025, the National Adaptation Policy Office coordinates climate resilience and adaptation policies across all governments and acts as a point of contact for businesses and communities. Key principles of the Strategy include coordination between different levels of government and businesses and communities to drive action and investments, and delivering climate information and services to help businesses and communities adapt. The 2022-23 Budget provided AUD 9.3 million to the Climate Risk and Opportunity Management Program, tasked with developing a National Climate Risk Assessment to assess the climate change risks and inform plans for adaptation and resilience. All states and territories have also developed adaptation plans.

To date, public policies in Australia have focused on emergency response and disaster recovery. In September 2022, a new National Emergency Management Agency (NEMA) was created by merging two previously existing agencies to deliver a more coordinated approach to emergencies and prepare for future hazards. The Disaster Recovery Funding Arrangements (DRFA), managed by NEMA, provides financial support to the state and territory governments to assist individuals and communities to recover from disasters. As part of the DRFA, states and territories are encouraged to incorporate resilience-building programs into the overall recovery. For instance, in May 2022, the Queensland Government announced the AUD 741 million Resilient Homes Fund, which is jointly funded with the Australian Government and is designed to help homeowners affected by flooding to raise, repair, retrofit or have their home voluntarily bought back. A similar AUD 700 million fund was announced in New South Wales. Also, in September 2022, the Australian Government committed AUD 200 million annually through the Emergency Response Fund for disaster prevention and resilience. There has been a similar focus on strengthening emergency preparedness and response capacities in other countries (OECD, 2023; Rodrigues et al., 2022; Verkerk,

Martinez de Arano and Palahí, 2018). In the United States, for example, public funding for wildfire suppression quadrupled from 1985-99 to 2000-19 (Roman, Verzoni and Sutherland, 2020), while it doubled in Greece between 1998 and 2008. However, the growing frequency and severity of wildfires have strained emergency response resources. For example, preparedness spending is estimated to have to double by 2071-2100 in the Canadian provinces of Alberta, British Columbia and Ontario to keep the current levels of success in wildfire response (OECD, 2023; Hope et al., 2016). In Australia, wildfire suppression has also become more costly, with the 2009 Black Saturday wildfires requiring more than one month of suppression to extinguish (Swiss Re, 2015). For these reasons, while emergency response and disaster recovery will need to remain well-funded, adaptation and risk prevention efforts that reduce the exposure of people and economic activities to natural disasters will have to take a more important role in improving resilience to climate change. In the last two decades, Australia has increasingly shifted to a resilience-based policy approach that considers broader factors relating to vulnerability and adaptation, starting with a National Strategy for Disaster Resilience in 2011 with further progress through the Natural Disaster Risk Reduction Framework which was released in April 2019.

Combining natural hazard information and land-use planning policies can be an effective adaptation policy. Land-use planning can limit development in more hazard-prone areas and mandate specific risk-prevention measures for new and existing constructions. For example, regulating building height and zoning density can reduce the spread of fire and increase fire resilience (Ganteaume and Long-Fournel, 2015). In Portugal, construction is forbidden in areas characterised by “high” and “very high” wildfire hazard (OECD, 2023; Presidency of the Council of Ministers, Portugal, 2021), but there can be exceptions if certain risk reduction measures are adopted. In certain countries like Greece and the United States, the lack of land-use regulations informed by wildfire risk assessments led to strong population growth in at-risk areas, contributing to higher wildfire impacts in recent years (Radeloff et al., 2018; Blandford, 2019; Triantis, 2022). In Australia, most buildings were built before the inclusion of wildfire risk consideration in planning and building regulations, and settlement patterns have resulted in low-density urban sprawl and rural-residential developments that encroach into fire-prone areas (Gonzalez-Mathiesen, Ruane and March, 2021). Spatial planning systems are the responsibility of states in Australia, and the degree to which land-use planning acts to mitigate risk varies across jurisdictions. In Victoria, the Planning Policy Framework ensures that the existence of bushfire hazard triggers planning and building permit requirements and that bushfire is considered in decision making. In New South Wales, appropriate consideration of bush fire hazards at the strategic planning phase is required under The Environmental Planning and Assessment Act. In ACT, bushfire risk is considered at all levels of land-use planning, particularly for areas susceptible to bushfires and areas proposed for urban development (ACT Government, 2019). However, all states currently permit homes to be built in bushfire and flood prone areas (Royal Commission, 2020). The consideration of natural disaster risk should be a requirement in all states and territories when making land-use planning decisions for new developments. There is also significant scope for hazard mapping data to be improved. In 2022, National Cabinet tasked Planning Ministers with developing a national standard for considering disaster and climate risk as part of land use planning and building reform processes.

Public policies can help to adapt the Australian economy to climate change by inducing reductions in vulnerability and exposure to climate hazards. Incomplete information or lack of public awareness of climate-related risks can lead to sub-optimal preparation and uninformed adaptation decisions by households and businesses (Economides et al., 2018). While recent climate-related disasters and public initiatives have heightened awareness, further efforts can be made to inform the public and encourage individuals and businesses to take protective measures and adapt to climate change more effectively. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology publish a State of the Climate Report providing climate projections every two years, and also provide this information on the Climate Change in Australia website along with various projections tools designed to help with planning for climate-related risk. The disclosure of climate-related risks could be made compulsory in certain cases such as the sale of residential or commercial properties, where sellers might

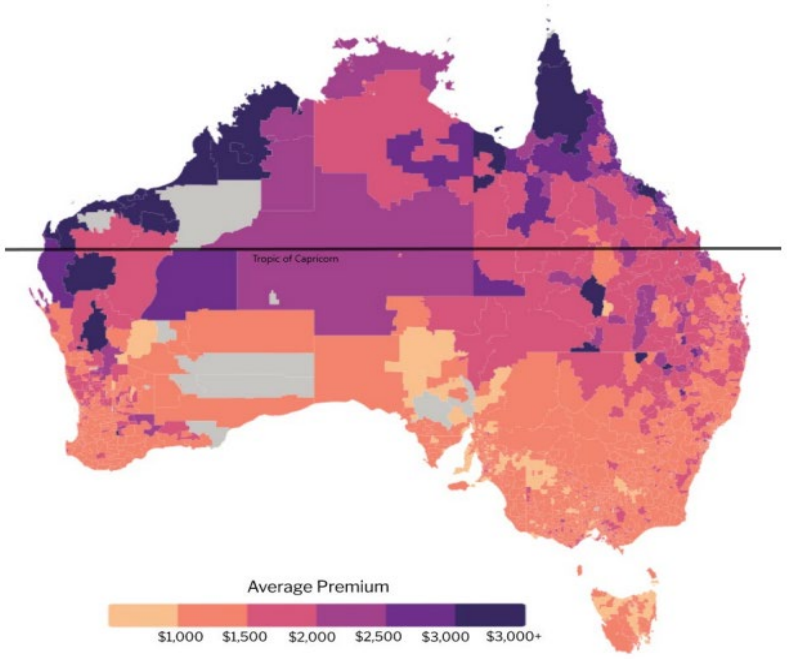
not have incentives to disclose this information. The Treasury has recently released a consultation paper proposing a broad range of companies and financial institutions be subject to the mandatory disclosure requirements. This would commence with the largest listed and unlisted companies for the 2024-25 financial reporting periods, with other companies phased in over time. These rules should cover as many types of entities as possible, which will require increased climate reporting capability.

Insurance premiums that better reflect climate and hazard risks provide an important price signal that can help households and businesses understand the risks they face and make better investment decisions. Wider dissemination of information on climate and hazard-related risks would also improve the insurance industry's assessment of climate risks and its ability to price these accurately (Productivity Commission, 2023), as well as help avoid the risk of insurers not providing insurance at all in certain regions given their inability to judge the risks. Disaster-related insurance claims have risen strongly, doubling from around AUD 1.5 billion per year in 2005 to AUD 3 billion in 2022 (Lefebvre and Reinhard, 2022). Expanding private insurance coverage can also limit the extent to which the government becomes the insurer of last resort, which can have high potential fiscal costs. Between 2010-11 and 2022-23, the Commonwealth Government has paid out more than AUD 16 billion to the states and territories through Disaster Recovery Funding Arrangements, and fiscal costs are projected to rise further. Private actors who expect the government to cover losses from large natural disasters have fewer incentives to minimize risks and invest in protection and resilient infrastructure. Clearer risk-sharing rules can reduce uncertainty over recovery from disasters and incentivise better private behaviour.

More elevated climate-related risks in northern Australia are driving considerably higher insurance premiums compared to the rest of the country (Figure 24), leading to higher rates of non-insurance in the region (ACCC, 2022). According to the Northern Australia insurance inquiry (ACCC, 2020), rates of non-insurance in northern Australia appear to be significant and rising, with estimates of home non-insurance rates of around 20% using Census 2016 data, higher than the estimated non-insurance rate for Australia overall, at around 11%. As a result, a public Cyclone Reinsurance Pool was established in July 2021, backed by a AUD 10 billion government guarantee and covering damages from extreme cyclonic winds, cyclone related flooding and storm surge. This Pool was introduced to improve insurance accessibility and affordability for households and small businesses faced with high insurance premiums. It includes incentives for residential risk mitigation by offering discounts for properties that undertake certain measures such as tying down their roofs or adding window protection. The Australian Competition and Consumer Commission (ACCC) is tasked with annually monitoring the impact of the Reinsurance Pool. It will be important to monitor whether savings from the reinsurance pool are being passed on from insurance companies to policyholders. Monitoring competition in the insurance sector and ensuring that there is public and transparent information on insurance costs will help ensure that insurance premiums are competitive. A national home insurance comparison website, as recommended by the ACCC, could improve competition in the insurance sector and provide households with better information (ACCC, 2020). Public reinsurance subsidises insurance premiums and risks distorting investment decisions (Productivity Commissions, 2023), and improved affordability of catastrophe insurance may disincentivise risk reduction and adaptation measures. Alternative policies include making climate disaster-related insurance coverage mandatory, as it is in Lichtenstein, which can help to improve insurability in high-risk areas via mutualisation (ECB and EIOPA, 2023).

Figure 24. Insurance premiums are particularly high in the hazard-prone North

Average premiums for residential combined building and contents insurance, 2021-22



Source: ACCC.

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Improving the resilience of infrastructure to extreme climate events will further reduce vulnerabilities to climate change. This is particularly important for new infrastructure given that it will last for many years. In the case of public infrastructure, fully incorporating adaptation concerns in the procurement process could establish a level playing field given that integrating climate resilience in procurement offers can be costly (OECD, 2018).

Agriculture will be particularly impacted by climate change through greater variability of rainfall and temperatures and a greater frequency of droughts, floods, wildfires and other extreme natural disasters. Recent studies suggest that farm profitability has already been impacted. For example, Hochman, Gobbett and Horan (2017) estimate that climate change has reduced wheat yields by 27% since 1990, and Hughes et al. (2022) estimate that it has reduced Australian farm profits by 23% in the last 20 years. Drought preparedness has been a focus of the Australian government's interventions in the agricultural sector (OECD, 2023). The *On-farm Emergency Water Infrastructure Rebate Scheme* was launched in December 2018 and includes AUD 100 million in funding for farmers to improve drought preparedness through the installation of on-farm water infrastructure. The *Future Drought Fund* provides AUD 100 million each year to help farmers and communities build drought resilience, and has allocated a total of AUD 420 million to drought resilience initiatives focused on improving climate information in the agricultural sector, improving the planning capacity of farmers, and promoting better practices. As a result of the focus on drought preparedness, wheat yield drought risk has shown a strong improvement since 2007-2008 as new practices have improved crop yields under dry conditions (ABARES, 2021). Rural Research and Development Corporations (RDCs) have been important vehicles for the government to support rural innovation. These constitute partnerships between the government and industry share funding and strategic direction-setting for R&D. Further prioritisation of R&D on adaptation technologies in agriculture could be considered.

Due to its central role in the transition to net zero, climate change adaptation in the energy sector is key. Rising temperatures and the increasing frequency of extreme heat not only affect energy demand (for cooling) but also energy supply by reducing the thermal capacity of transmission lines, reducing the efficiency of power plants, and causing failures (Ke et al., 2016). While the Electricity Sector Climate Information Project provides important information on climate risks for the electricity sector, including climate projections at a granular location level, Australia has not undertaken a fully comprehensive assessment of the impacts of climate change on the energy sector (IEA, 2023). A National Adaptation Plan, announced in the 2023-24 Budget, is currently under development. This should include plans specifically for the energy sector, to identify priorities and co-ordinate further action.

Recommendations for achieving the transition to net zero in Australia

MAIN FINDINGS	RECOMMENDATIONS (Key recommendations in bold)
Establishing a long-term national emissions reduction strategy	
Diverse emission reduction targets and policies at the state and territory level imply different costs of emission abatement across states and will come at a higher cost than a nationally coordinated strategy.	Improve coordination of climate transition policies between federal, state and territory governments.
Achieving emissions reductions in Electricity, Mining, Industry, Transport, Agriculture and Buildings	
The development and deployment of clean energy technologies and electricity transmission infrastructure is a key component of the transition to net zero. Australia's public spending on energy research, development and demonstration is significantly below the IEA average. It is also unclear whether current policies will achieve the necessary increase in renewable energy generation, storage and transmission.	**Consider scaling up and refocusing public funding towards the development and demonstration of clean energy and energy-efficiency technologies.** **Stand ready to provide further policy support and accelerate the planning and implementation of renewable energy projects to ensure that renewable energy targets are met.**
Emissions baselines (or limits) under the Safeguard Mechanism have been tightened and will decline by 4.9% per year until 2030. Facilities that reduce their emissions below their baseline will earn credits. Facilities that are both highly emissions-intensive and trade-exposed will be able to apply for slower baseline decline rates.	**Switch to limits on total emissions if the current Safeguard Mechanism baselines based on emissions intensity fail to deliver the desired emissions reductions, and consider broadening the coverage of the mechanism.** Regularly review whether the baseline decline rates under the Safeguard Mechanism are appropriate, along with the special treatment of emissions-intensive, trade-exposed facilities.
Given that industrial facilities under the Safeguard Mechanism can meet their baselines by using carbon offsets, it is imperative to ensure their credibility and integrity. A recent independent Review of Australian Carbon Credit Units produced a list of 16 recommendations to improve their integrity, which the government has supported in principle.	Fully implement the recommendations in the Review of Australian Carbon Credit Units.
Existing energy efficiency certificates, such as the New South Wales Energy Savings Scheme, have seen little take up from small industrial facilities. This is in part due to the fact that plant-specific efficiency measures are difficult to standardize and compare across facilities.	Focus energy savings schemes in industry on energy savings from common industrial equipment. Consider establishing a federal energy savings scheme.
Transport is projected to become the largest source of emissions in Australia by 2035. Vehicle fuel efficiency is low in Australia and will need to increase rapidly to achieve emissions targets, along with a quick take-up of electric vehicles. Fuel economy standards for light vehicles are currently under elaboration. States have introduced various policies to promote purchases of electric vehicles, including rebates, stamp duty exemptions, and free registrations, which come at a high fiscal cost.	**Align the various state subsidy programmes for electric vehicles and introduce stringent federal fuel economy standards.** Relax import restrictions on low- and zero-emissions vehicles. Consider introducing fuel economy standards for trucks and other heavy vehicles.
On-road heavy vehicles are currently eligible for a reduced fuel tax in Australia, and businesses pay no fuel tax on fuels used for off-road vehicles.	Reduce or eliminate fuel tax exemptions for heavy vehicles and machinery.
Australia currently has a very low amount of charging points per electric vehicle. Further increasing demand for electric vehicles will require drastically increasing the number of public charging points.	Further increase public funding of electric vehicle charging infrastructure.
Public revenues from the fuel excise will collapse if internal combustion engine vehicles are replaced by electric vehicles.	Consider extending the use of distance-based road user charging.
There is no specific emissions reduction target for the agriculture sector. Such a target could be helpful to focus mitigation efforts, measure progress and send an important signal to the industry.	Consider introducing a specific emissions reduction target for agriculture.
Overall public support to agriculture is low (0.2% of GDP), with a focus on market openness, building climate resilience, and investments in public goods, including research and development, hydrological infrastructure and biosecurity. Extension services and agricultural education receive smaller amounts of funding.	**Further increase support for agricultural research and development as well as extension services and agricultural education, with a particular focus on emissions reduction technologies and practices.**
Agriculture has the potential to become an important source of carbon offsets but there have been very few agricultural projects that have generated Australian Carbon Credit Units to date. There are few eligible agricultural methods under the Australian Carbon Credit Units Scheme and the administrative costs of submitting projects can be high for smaller farms.	Expand the list of agricultural methods eligible under the Australian Carbon Credit Units Scheme while ensuring their additionality and effectiveness in reducing emissions. Streamline administrative processes to participate in the Scheme and provide direct support to potential scheme participants through capacity building programmes.

Further electrification and strong improvements in energy efficiency are required to significantly reduce emissions from buildings. The Nationwide House Energy Rating System (NatHERS) is voluntary and does not cover existing housing and rental properties.	**Regularly update energy efficiency requirements in the National Construction Code.** Implement a disclosure obligation of the NatHERS rating, especially for rental properties.
Retrofitting the existing housing stock to make it more energy efficient is a crucial priority to achieve decarbonisation targets. However, energy efficiency standards can imply large costs, which can weigh particularly on lower-income households.	Consider introducing targeted support at state level for low-income households to improve the energy efficiency of existing housing.
Addressing the challenges and opportunities of the labour market transition	
Although the absolute number of workers in coal mining is not large, jobs are highly concentrated geographically in regional parts of Queensland, New South Wales, and Western Australia.	Target place-based policies such as re-training, up-skilling and public investment programs in the regions most dependent on employment in fossil fuel industries.
Renewable energy will be a major source of jobs in Australia. However, half of the workers needed for the renewable energy transition are needed in an occupation currently facing national shortages and requiring formal education and training. Participation by women in some of these occupations (e.g. electricians and engineers) is very low. Public spending on training programs in Australia is also low compared to other OECD countries.	Establish a comprehensive survey of future employment needs in the energy sector. Consider policies to promote greater enrolment of women in education or vocational training for key energy sector occupations, such as apprenticeship subsidies and free or low-cost training programmes. Consider increasing funding for active labour market policies including job-search and training schemes.
Adapting to climate change	
Australia is particularly exposed to climate-related hazards. Informing the public and raising awareness can encourage individuals and businesses to take protective measures and adapt to climate change more effectively.	**Consider improving the disclosure of climate and hazard-related risks in certain cases such as the sale of residential or commercial properties.**
Land-use planning is the responsibility of states and territories in Australia, and the degree to which climate hazard information is used for spatial planning varies. Land-use planning can limit development in more hazard-prone areas and mandate specific risk-prevention measures for new and existing constructions.	**Require all states and territories to consider climate and hazard risk when making land-use planning decisions for new developments**.
Agriculture will be particularly impacted by climate change through greater variability of rainfall and temperatures and a greater frequency of droughts, floods, wildfires and other extreme natural disasters. The Australian government's adaptation interventions in the agricultural sector have focused on drought preparedness, with less of a focus on R&D and extension services.	Further prioritisation of R&D on adaptation technologies in agriculture could be considered.
Rising temperatures and the increasing frequency of extreme heat constitute a key risk for the energy system. Australia has not undertaken a fully comprehensive assessment of the impacts of climate change on the energy sector to date.	Develop a national adaptation plan specifically for the energy sector to identify priorities and co-ordinate further action.

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