Australia 2023

Energy Policy Review

International Energy Agency

INTERNATIONAL ENERGY AGENCY

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Foreword

The mission of the International Energy Agency (IEA) is to shape a secure and sustainable energy future for all. We work with countries around the world on strengthening energy security and reaching net zero emissions. Our in-depth reviews are an essential IEA tool for providing insight and advice to governments on how to best achieve their energy and climate goals.

Since the last IEA review of Australia in 2018, the government has significantly raised its climate ambitions, with the 2022 Climate Change Act doubling the target for emissions reductions by 2030 and setting the goal of reaching net zero emissions by 2050. Australia also signed up to the Global Methane Pledge in 2022, joining 130 governments who are collectively targeting a reduction in methane emissions of at least 30% by 2030 across all sectors.

Since the last review, Australia has continued to achieve remarkable growth in solar PV and now aims for clean electricity sources to account for over 80% of its power mix by 2030. To adapt to this change, Australia's power system needs to quickly enhance its flexibility through interconnections, storage and a diverse renewables portfolio. The Government's Powering Australia Plan and the Capacity Investment Scheme are important initiatives in this regard.

Australia remains a major exporter of energy and of the critical minerals that are used in many clean energy technologies. It has sought to drive progress in the areas of hydrogen, critical minerals and resilient supply chains – all essential pillars of our future energy security and the global energy transition. These priorities were reflected at the Sydney Energy Forum in 2022, which was co-hosted by the Australian Government and the IEA. I would like to thank Prime Minister Anthony Albanese and Energy and Climate Minister Chris Bowen for their leadership and engagement with the IEA on these issues.

I hope that the recommendations set out in this report will help the country accelerate its energy system transformation while ensuring affordable and secure energy supplies.

Dr Fatih Birol

Executive Director

International Energy Agency

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1. Executive summary

Energy transition towards net zero

Since the International Energy Agency's (IEA) last review of Australia in 2018, the Australian Government has stepped up its climate ambition at the federal level, building upon the goals and policies of states and territories.

In June 2022, the Australian Government submitted a revised 2030 Nationally Determined Contribution (NDC), pledging a 43% reduction of greenhouse gas (GHG) emissions by 2030 from 2005 levels, an increase from the previous government's target of 26-28%. This target was legislated alongside the NDC commitment to achieve net zero emissions by 2050 in the Climate Change Act 2022. Australia caught up with the pace of emissions reductions pledged by other advanced economies and more closely aligns with a trajectory compatible with the Paris Agreement. In October 2022, Australia joined the Global Methane Pledge.

Reaching the 2050 target is possible but will require a clear policy road map with key milestones by sector and policy area to 2050. Monitoring progress based on a coherent energy transition data strategy will be critical to allow early corrective actions to be taken. As stipulated under the Climate Change Act 2022, the government will present an Annual Climate Change Statement to Parliament. The first one was presented in December 2022. The statement can indeed serve as an annual progress review of Australia's energy transition.

Existing strategies need to be updated in the context of Australia's higher near-term emissions reduction goal and net zero targets, including the Long-Term Emissions Reduction Plan. The net zero commitment requires a faster trajectory and increased efforts in energy efficiency and renewable energy. The Australian Government is taking a collaborative approach with states and territories under the new National Energy Transformation Partnership (NETP) with a broad scope of action. The NETP focuses on consumers, energy market reforms, technology development, manufacturing in Australia, job creation, and the underpinning requirements to create a just and inclusive energy transition.

Australia's focus on deploying low emissions technologies over the past two decades means that 72% of total government expenditure of AUD 21 billion was spent on commercialisation, while only 23% was spent on energy-related research and development (R&D) and 6% on demonstration. The government and state-owned energy RD&D budget peaked in 2013 at AUD 1 124 million, but dropped thereafter before reaching AUD 460 million in 2021. By international comparison, public funding for energy RD&D accounted for 0.019% of gross domestic product (GDP) in 2020, half the IEA average. This does not reflect Australia's research and development tax incentive which is an important driver for innovation investment by the private sector.

Australia's energy transition will require a whole-of-government just energy transition strategy at both federal and state and territory levels, boosting job opportunities and skills for the transition and securing the social licence to construct and operate the necessary infrastructure. Australia is taking active steps on reskilling and jobs under the forthcoming Energy Workforce Strategy to transform its energy and mineral resources sector into higher value products for exports, creating new manufacturing jobs and export-ready technologies.

Key role for energy efficiency

Under the National Energy Productivity Plan (NEPP), the Australian Government, jointly with states and territories, committed to an energy productivity target of a 40% improvement between 2015 and 2030.

IEA analysis confirms that energy efficiency improvements have allowed Australia to achieve energy savings since 2000 in industry and services sectors thanks to efficiency disclosure regimes and labelling as well as the GEMS product efficiency standards. However, between 2015 and 2019, annual improvement rates slowed down to around 1.9% per year, similar to trends in other countries. There is a need to accelerate action and annual improvement rates from their recent drag to bring Australia back on track to reach its target and closer to net zero. Transport and residential buildings have the greatest productivity potential.

Higher energy efficiency benefits or 60% productivity improvements could be expected from a net zero aligned trajectory, which would require an annual improvement of 4.2% between 2020 and 2030 on average according to the global IEA net zero road map. The Australian Government estimates that a 53% improvement could be achieved if the measures proposed by the end of 2021 are implemented. Hitting the target would mean Australia could decrease its energy consumption while GDP continues to increase.

It is welcome that the Australian Government is proposing stricter standards and policies, notably for the high potential transport and residential buildings sectors. In the transport sector, the National Electric Vehicle Strategy is an opportunity to raise the efficiency savings of and decarbonise the transport sector. As part of the strategy, Australia is considering introducing fuel economy standards. The revision of the National Construction Code with efficiency standards for new builds and large-scale renovations is another positive development. The revision is supported by the expansion of the home energy rating scheme to include energy used by appliances, not just the home's thermal shell.

To reach an early peak in emissions and address upwards pressure on energy bills due to the global energy crisis, accelerating energy efficiency can reduce household and business energy expenditure and is, therefore, more relevant and urgent than ever. The government must confirm the role of energy efficiency and the expected share in achieving Australia's climate ambition and scale up policies and measures to unlock efficiency upgrades and higher productivity across the economy.

The Department of the Treasury forecasts a 56% hike in electricity prices over financial year 2022-2023, with gas prices rising by 44%. The Australian Competition and Consumer Commission (ACCC) confirmed that electricity bills have jumped by AUD 300 on average since April 2022. This is the equivalent of a 25% increase for the median residential household in the National Electricity Market (NEM) and AUD 1 500 for small businesses. The ACCC retail pricing inquiry of 2018 found that 30% of the lowest income households

spend 8% on fuel, but this has greatly increased since. Judging by the United Kingdom fuel poverty definition (10% of lowest income households), energy poverty is becoming an issue.

The critical importance of lowering energy bills has also been emphasised by the new Australian Government's election commitment to reduce consumer energy bills by AUD 275 per household by 2025. The IEA's 2022 *Energy Efficiency Market Report* also confirms how living in a more efficient home and driving a more efficient car can save consumers up to 70% of their household energy bill.

Towards a largely decarbonised power generation in 2030

Renewable energy has seen remarkable growth, meeting all incremental electricity demand in the past decade thanks to the Commonwealth Large-scale Renewable Energy Target and the state-based auctions. Renewable electricity generation quadrupled between 2000 and 2021, from 17.6 terawatt hours (TWh) to 70.3 TWh, pushing up the national share of renewables from 8% to 27% in electricity generation. Most of the growth stems from solar photovoltaics (PV), as high state-level targets and power purchase agreements (PPAs) are driving the expansion of utility-scale renewables. At the household level, Australia has the highest penetration in the world, with one in three households having solar PV installations.

Up to 2027, the IEA forecasts Australia's renewable energy capacity to expand by 85% to reach 40 gigawatts (GW), thanks to the introduction of ambitious targets and increased clean energy funding at federal and state levels, PPAs, and new projects announced in the renewable energy zones (REZ). Provided Australia can accelerate the implementation of the REZ and related grid projects alongside additional coal retirements, the IEA expects 57 GW of renewable electricity capacity to be achieved by 2027. This forecast also includes Snowy Hydro adding 2 GW by 2026 or 2027. Grid development and new wind power deployment will require more community engagement and the work of the Energy Infrastructure Commissioner is important in this regard. While commissioning lead times decreased for onshore wind projects, they increased for distributed solar PV projects, notably due to the introduction of grid fees and higher system costs.

In the NEM, the Australian Electricity Market Operator (AEMO) expects renewable energy to account for 83% by 2030 as part of the Step Change Scenario, which is aligned with the Australian Government's plans of reaching 82% of renewables in the national electricity mix. The Australian Government places an emphasis on promoting major infrastructure investment to "rewire the nation" and agreed under the NETP that an emissions reduction goal would be enshrined into the National Electricity Objective alongside security, competition and affordability objectives.

The NEM will see a major energy system transformation, with a substantial loss of dispatchable capacity in the coming decade. Changing generation economics and the age of the plants are accelerating closure decisions. Lignite use in power generation is expected to end in 2032, according to the AEMO. There is no clarity provided on the speed of coal retirements. The AEMO's Integrated System Plan (ISP) expects 14 GW of the 23 GW current coal capacity in the NEM to be retired by 2030, while coal plant owners have so far announced the retirement of 8.4 GW. The Australian Government only requires a minimum three-year notice from coal-fired power plant owners for plant closure.

Considerable uncertainty remains on the pace of clean energy investment at the right time and in the right place and the system integration and flexibility needs in generation and storage; demand response and grid investment; and workforce, supply chain and community needs. An implementation plan for the NETP could provide guidance on the road map for the transformation. In December 2022, energy ministers endorsed in principle a new Commonwealth Capacity Investment Scheme to help reduce investment uncertainty and price volatility by underwriting investment in zero emissions dispatchable capacity, including storage.

Maintaining energy security during the transition

Australia has a vast natural resource base of renewables, critical minerals and fossil fuels. Today, it is one of the largest energy exporters in the world and has the stated ambition to become a renewable energy export superpower in the future. Australia produces a breadth of critical minerals, including lithium, of which it is the largest producer in the world, and cobalt and rare earth elements.

The Russia Federation's (hereafter "Russia") invasion of Ukraine in February 2022 has created a new set of energy security challenges both internationally and domestically for Australia with regard to energy security and energy affordability. A combination of factors led to a natural gas and subsequent electricity crisis in June 2022, including the delayed maintenance of generation plants post-Covid-19, the flooding of coal mines, the higher gas demand in July (during a colder winter in the southern hemisphere), and very high international prices for natural gas and coal. The June 2022 crisis saw the temporary introduction of administered price caps in the east coast gas market and the suspension of the NEM.

The crisis has prompted the Australian Government to consider a range of reforms to increase its resilience against such events across the gas, oil and electricity sectors.

Since the last IEA review in 2018, the government has carried out major reforms in its energy markets, prompted by the Finkel Review of 2017 and the 2016 South Australia blackout. Many of the IEA's 2018 recommendations have been implemented. The NEM regulatory rules and system operation are being adapted to higher shares of variable renewables based on key reforms, such as the AEMO's ISP and its REZs, alongside the introduction of the five-minute settlement and new ancillary services markets. The Energy Security Board progressed longer term market design reforms with the post-2025 market design framework.

Compared to market operators in other jurisdictions, the NEM's rules grant the AEMO more power to directly intervene at times of market stress. This includes applying a wholesale market price cap and a price floor, to direct generators to run (which triggers generators' rights to apply to the Australian Energy Market Commission [AEMC] for compensation), to direct load shedding, and to suspend the market. These AEMO directions come at a substantial and rising cost, notably for maintaining frequency control and procuring ancillary services. The AEMO can procure out-of-market reserves through the Reliability and Emergency Reserve Trader. However, the NEM has no obligatory arrangements for power generators to hold oil/gas/coal fuel in storage.

The June 2022 electricity crisis reinforces the urgency and the need for an orderly transition in the NEM. Based on the AEMO's and the Australian Energy Regulator's (AER)

analysis of the crisis and its upcoming recommendations, the government should expedite a review of the reliability approach taken by the AEMC.

A period of sustained high international fossil fuel prices cannot be excluded in the short term as global liquefied natural gas (LNG) investment is subdued and the global LNG market is expected to remain tight through 2025. With the start-up of LNG exports from the east coast and rising global demand and prices, Australia has also seen rising domestic gas prices, which are increasing in step with LNG netback prices. This is a unique situation for a producer and exporter.

The Australian Government is commended for the east coast gas market reforms and the more robust approach to ensuring adequate supplies. In 2022, it started a review of the Australian Domestic Gas Security Mechanism and adopted the necessary rules for the transition to low-emission and renewable gases. Based on the results of the ACCC's latest inquiries, the Australian Government should implement the new Heads of Agreement with LNG producers by ensuring adequate and affordable gas for the domestic market. The IEA urges the government to review incentives for gas storage investment and LNG import terminals.

Net imports of oil products have increased sharply following significant refining capacity rationalisation, and with oil demand expected to grow in the coming decade, net imports will likely rise further. The Australian Government has placed a strong focus on improving the security of oil supply in recent years, particularly through the various measures included as part of the 2020-2021 and 2021-2022 Budgets. The government has taken steps to ensure that Australia's two remaining refineries remain open in the short term and to increase diesel storage capacity. It is also planning to implement a minimum stockholding obligation on oil suppliers. The government should also strengthen efforts to reduce oil consumption, particularly in the mining and transport sectors, which are the main drivers of oil demand growth. Once the IEA collective actions end, the government should take all necessary measures to increase its oil stock levels to comply with its IEA stockholding obligation.

One of Australia's major security challenges is its high exposure to more significant and more frequent extreme weather events, such as storms, flooding, wildfires and heat waves. The energy sector, from mining to renewables and grids, will need to adapt to the impacts of climate change. Australia has not yet completed a comprehensive assessment of climate change impacts on the energy sector outside of electricity. Developing a national-level energy sector plan that lays out future steps for climate resilience could further guide and accelerate co-ordinated action.

Key recommendations

- Review Australia's emissions reduction plan taking a consultative approach to emissions reduction pathways, inclusive of the energy, agricultural, land-use, industry and waste sectors. For 2030, elaborate, jointly with states/territories and various stakeholders, a national climate and energy strategy which lays out the milestones and actions.

- Step up national energy efficiency polices and measures and clarify the role of efficiency in achieving Australia's climate goals and reducing energy bills. Introduce specific energy efficiency and savings targets and support programmes, notably for the energy poor.
- Ensure adequate infrastructure and policies are in place to guarantee the security of fuel supply domestically while pursuing efforts to strengthen long-term energy security by accelerating the uptake of energy efficiency, renewables and low-emission fuels.
- Agree on the critical energy market reforms as part of the National Energy Transformation Partnership to mobilise private sector investment and ensure reliability. Streamline the regulatory landscape of the NEM and agree jointly with states/territories on policies and measures towards 2030 and 2035 for:

  i. decarbonisation of the energy sector, including through energy efficiency
  ii. affordability and consumer engagement
  iii. energy system reliability and climate resilience
  iv. research, innovation and commercialisation
  v. workforce development and reskilling.

- Adopt a people-centered transition approach and evaluate reskilling, jobs and growth impacts on communities and workers. Develop the social licence with citizens and communities for infrastructure through community engagement. Ensure the Office of the Australian Energy Infrastructure Commissioner is fully resourced to support communities and project developers.
- To track the progress of Australia's energy transition, create an appropriately resourced national energy and climate information system, including end-use energy and prices data, a national energy forecast and market data function, enlarged scope for mandatory reporting on natural gas and new fuels, while strengthening data governance and removing barriers to data sharing across government.

2. General energy policy

Key data

(2021)

TES: 5 439 PJ, +2.88% since 2010

TES by source: oil 32.3%, coal 31.6%**,** natural gas 27.7%, solar and wind 3.8%, bioenergy and waste 3.6%, hydro 1%

Energy intensity per capita (TES/capita): 213.4 GJ/capita in 2020 (IEA average: 160.3 GJ/capita); -11% since 2010

Energy intensity per GDP (TES/GDP): 5.4 MJ per 2015 USD PPP in 2020 (IEA average 4.7 MJ per USD); -16.2% change since 2010

TFC: 3 307 PJ; +0.06% from 2011 to 2021

TFC by sector: transport 37.8%, industry 39.0%, buildings 23.2%

Country overview

Australia is a federation of six states (New South Wales, Queensland, South Australia, Tasmania, Victoria and Western Australia) and two mainland territories, the Australian Capital Territory and the Northern Territory.

Australia is a parliamentary monarchy with King Charles III of the United Kingdom as head of state. He is represented by the Governor-General of the Commonwealth of Australia, His Excellency, General the Honourable David Hurley AC DSC (Retd). The prime minister leads the executive branch of the Australian Government. The legislative branch is composed of the House of Representatives and the Senate, together making the Australian parliament. The judicial branch consists of the Commonwealth, state and territory courts. In the 2022 federal election, held on 23 May 2022, the Australian Labor Party came to power with the Honourable Anthony Albanese as prime minister of Australia and the Honourable Chris Bowen MP as Minister for Climate Change and Energy.

Australia has seen constant population growth, reaching 25.7 million inhabitants in 2022. Australia has a high GDP per capita and a relatively low poverty rate. The country's GDP grew for more than 20 years without a recession, achieving USD 61 632 per capita in 2022. In 2019, the country experienced a GDP downturn and has recently seen a slowdown in its economic growth, with an expected growth rate of its GDP of 2.5% for 2022 (OECD, 2022). The economic recovery is projected to continue, with real GDP growth reaching 4.2% in 2022, supported by high commodity prices and improved terms of trade. Australia's unemployment rate was 4.0% in March 2022, lower than the OECD average of 5%.

Energy production, supply and demand

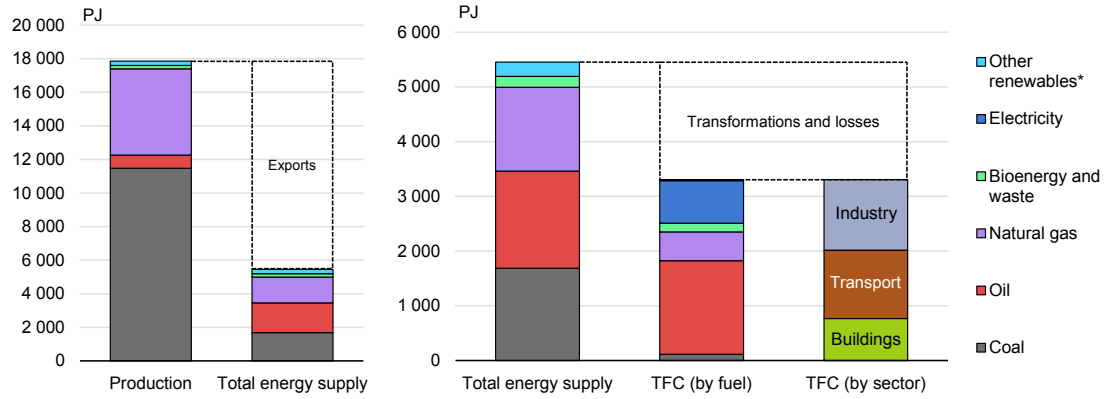
Thanks to a wealth of natural resources, Australia is one of the largest energy exporters in the world, specifically of LNG, coal and minerals. The People's Republic of China (hereafter "China"), Japan, Korea and the United States are the largest export markets for Australia.

In 2020, energy production – mainly coal and natural gas – was more than three times higher than the country's total energy supply (TES).

Australia is the fourth-largest coal producer in the world, after China, India and the United States. In 2020, coal production was 7.6 higher than the country's needs (TES). Since 2015, Australia has significantly increased the production of natural gas and exports of LNG. Its natural gas production was 3.4 more than the amount used domestically. Australia also produces a significant amount of crude oil, covering 47% of oil TES.

Total energy supply is strongly dominated by fossil fuels, covering 92% of the total in 2021. Oil accounts for one-third of TES, followed by coal (32%) and natural gas (28%). Coal is mainly used in electricity generation, while oil is directly used primarily in transport and accounts for more than half of total final consumption (TFC). Transport is the largest sector for energy consumption (39% in 2020), followed by industry (38%) and buildings (23%).

Figure 2.1 Overview of energy production, supply and demand in Australia, 2021



Australia exports a large share of the energy it produces, mainly coal and natural gas.

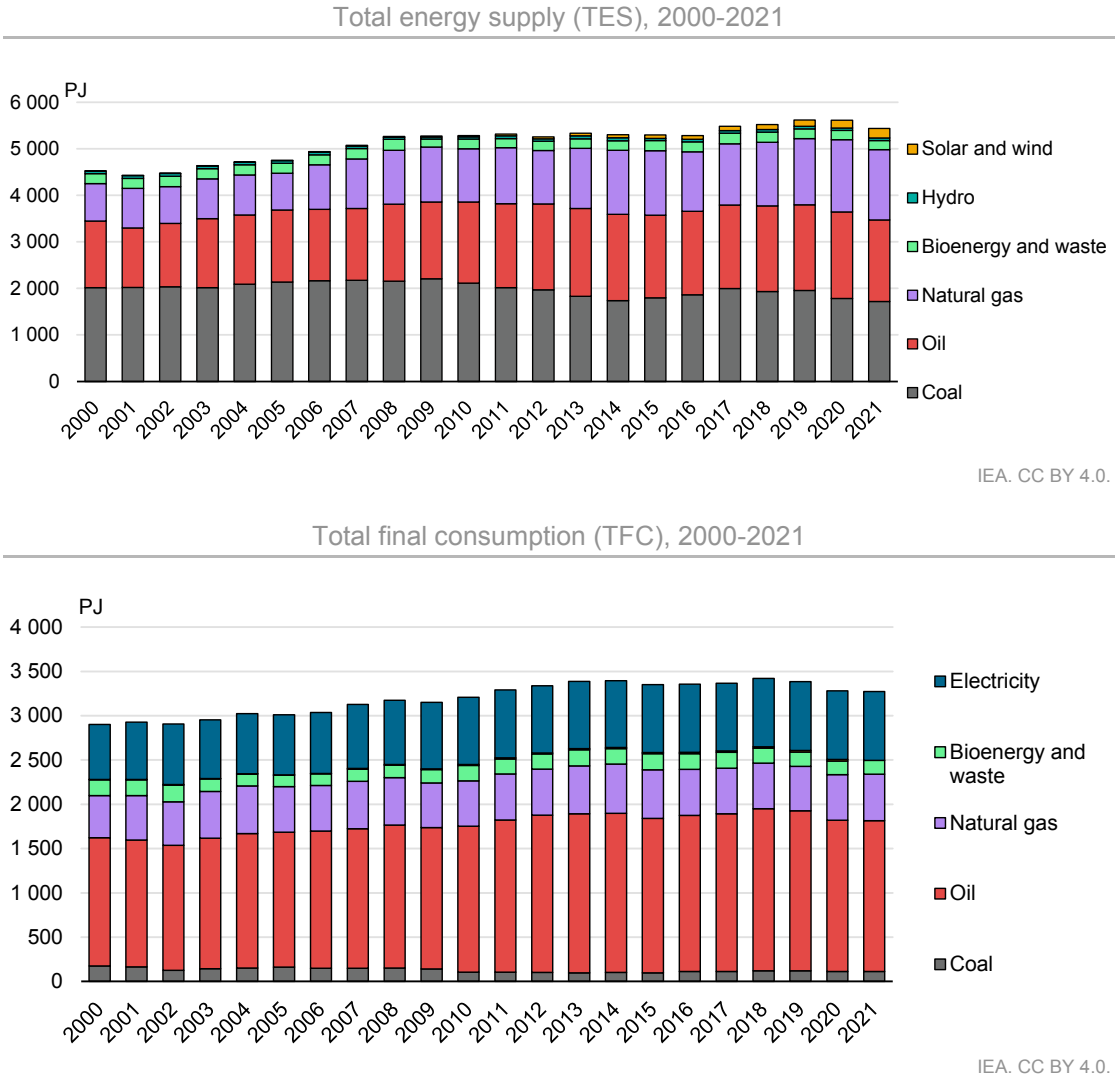
*Other renewables include hydro, solar and wind.
Note: PJ = petajoule. Source: IEA (2022).

Coal, oil and natural gas dominate TES. While the share of oil has been stable at around 34% since 2015, the share of coal declined to a record low of 30% in 2020 while that of natural gas increased to 29% in the same year. Australia has seen a continuous increase in TES of renewable energy sources thanks to the increasing share of solar and wind, which together accounted for 3.8% of TES in 2021, and a stable contribution of bioenergy and waste (around 4%) and hydro (1%).

Energy consumption (TFC) increased by 9% from 2010 to 2019. As elsewhere, because of the Covid-19 pandemic, consumption dropped by 3% in 2020, compared to 2019, notably in the transport sector.

TFC is dominated by oil, covering 52% of the total in 2021. The share of electricity was stable at around 22% until 2021, when it rose to 24%, as electricity demand increased, especially in the residential sector. Demand for natural gas has increased over time, mainly from the buildings sector, and accounted for 16% of TFC in 2024. Bioenergy is primarily used for residential space heating and accounted for 4.8% of TFC in 2021, while coal used in industry covered 3.4% of TFC.

Figure 2.2 Total energy supply and demand by source in Australia



Fossil fuels dominate total energy supply, with rising contributions of natural gas and oil and a decreasing role of coal. Total final consumption is largely covered by oil.

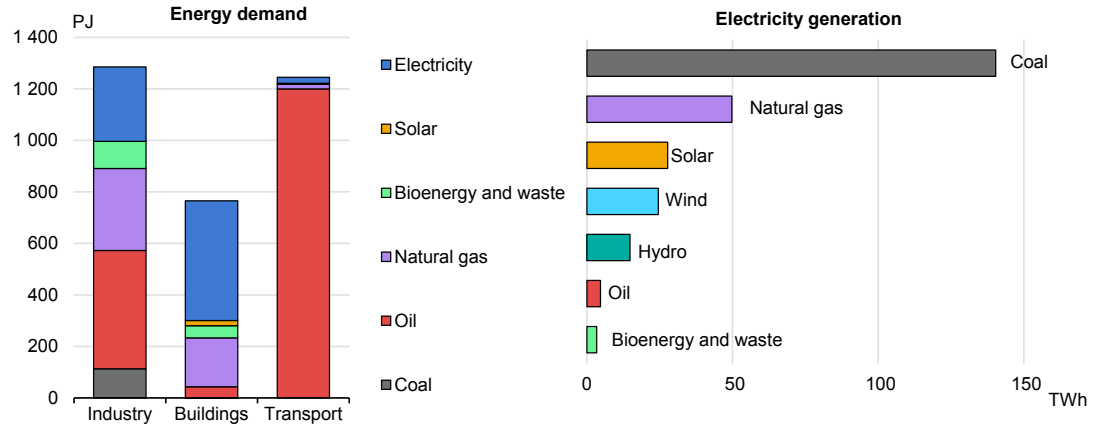
Note: PJ = petajoule.
Source: IEA, (2022).

Oil-fuelled transport was the most energy-consuming sector in 2021, despite its consumption falling by 10% with respect to 2019. Energy consumption in the industry

sector is more diversified and covered by oil (36% in 2021), natural gas (25%), electricity (22%), coal (9%) and bioenergy and waste (8%). The main energy source for the buildings sector is electricity (61%), followed by natural gas (25%), minor shares of bioenergy and waste (6.2%), oil (5.7%) and solar thermal (2.6%).

Coal still dominates electricity generation (53% in 2021), but its share has significantly decreased since 2010, when it was 71%. On the contrary, the share of natural gas increased from 18% to 21% from 2010 to 2020, but decreased to 19% in 2021. In recent years, electricity generation from renewables is growing at a fast pace: solar increased threefold from 2018 to 2021, when it accounted for 10.5% of the total, closely followed by wind at 9.3% and hydro at 5.6%.

Figure 2.3 Energy demand per sector and fuel, and electricity generation by fuel in Australia, 2021



Notes: PJ = petajoule; TWh = terawatt hour.
Source: IEA, (2022).

Key institutions

The Commonwealth government (hereafter the Australian Government) has constitutional responsibility for trade, foreign relations (including international climate change), defence and immigration. States are responsible for energy production (including from renewable and non-renewable sources), land use, forestry, transport, mineral rights and environmental assessments (except offshore). Justice, health, education and consumer affairs are shared responsibilities.

Most of the policies on energy and environment, and on wholesale/retail energy markets (electricity and natural gas) require collaboration. On 30 September 2022, the National Cabinet agreed to establish the Energy and Climate Change Ministerial Council (ECMC). This council replaces the former Energy National Cabinet Reform Committee, which was preceded by the COAG Energy Council. Involving all jurisdictions in Australia, Commonwealth and local governments, the Energy and Climate Change Ministerial Council aims to deliver on the National Energy Transformation Partnership (NETP) across national energy, climate change and adaptation priorities.

In the area of energy, the Australian Energy Ministers Meetings (EMM), composed of the Australian Government and the state governments has been the forum to enable co-

ordination on energy market reforms in the National Electricity Market (NEM) and the east coast gas market. The NEM brings together five regional market jurisdictions – Queensland, New South Wales (including the Australian Capital Territory), Victoria, South Australia and Tasmania. Western Australia and the Northern Territory are not connected to the NEM. The EMM agree national rule-making under the National Electricity Law, the National Gas Law and the National Energy Retail Law, among others.

Under the Australian Government, the Department of Industry, Science and Resources manages the broad portfolio of natural resources, e.g. upstream (oil/gas/coal), minerals and mining regulation, and buildings, as well as supply chain resilience. It also guides the work of the Australian Building Codes Board and scientific advisory bodies. Constituted by the Science and Industry Research Act 1949, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is the national scientific research agency under the Department of Industry, Science and Resources. Other bodies are involved in climate science, including the Bureau of Meteorology, which advises on climate change impacts and science, and the National Climate Science Advisory Committee.

The National Offshore Petroleum Titles Administrator is responsible for administering petroleum and GHG titles in Commonwealth waters. The National Offshore Petroleum Safety and Environmental Management Authority is the national regulator for certain aspects of offshore oil and gas operations, and administers the Offshore Infrastructure Regulator, that oversees the offshore renewables industry.

The new Department for Climate Change, Energy, the Environment and Water (DCCEEW) has responsibility for gas, electricity, energy efficiency, climate change policies and regulatory aspects (including energy security) alongside net zero technology and innovation. The department is directly engaged with international energy and climate policy. The DCCEEW also oversees the activities of several government agencies for clean energy: the Australian Renewable Energy Agency (ARENA), the Clean Energy Finance Corporation (CEFC), the Clean Energy Regulator (CER) and the Climate Change Authority (CCA). The CEFC is the largest government-owned green bank in the world.

The Department of Foreign Affairs and Trade (DFAT) is responsible for international climate finance policies and overseeing investment and trade, notably in the resources and energy sectors. The Department of Infrastructure, Transport, Regional Development and Communication is responsible for transport policies, including vehicle emission standards.

Under the NEM rules, the Commonwealth has provided for greater self-governance of the national electricity and gas markets through independent authorities. NEM energy markets are overseen by three main market authorities with overlapping competences and areas of responsibility: the Australian Energy Regulator (AER) oversees wholesale/retail energy markets and the federal economic regulation of energy networks. The AER is a constituent part of the Australian Competition and Consumer Commission (ACCC) and shares its resources but is independent in its financial and executive decisions by the board. The Australian Energy Market Commission (AEMC) is the supervisory body of electricity and gas markets, independent from Commonwealth or state governments. The AEMC is the rule maker for the NEM. The Australian Energy Market Operator (AEMO) operates Australia's largest gas and electricity markets and

power systems – ten gas hubs and the NEM, and the wholesale electricity market and the power system in Western Australia. The AEMO is 60% government owned and 40% privately owned but funded through fees. The Energy Security Board was created following the 2017 Finkel Review. It brings together the heads of the AEMC, the AER and the AEMO. Its main task is to foster co-ordinated rule making across the NEM with regard to reliability, security and emissions reduction policies. The NEM has a commitment to consumer outcomes under the national energy objective and is mainly represented by Energy Consumers Australia.

Set up under the Treasury, the ACCC is an independent Commonwealth statutory authority whose role is to enforce the Competition and Consumer Act 2010 and a range of additional legislation, promoting competition, fair trading and regulating national infrastructure through the AER in the energy sector (gas and electricity). However, the National Competition Council, a research and advisory body, deals with regulating third-party access to services provided by monopoly infrastructure.

Box 2.1 OECD Best Practice Principles on the Governance of Regulators

Australia has a strong track record in working with dedicated regulatory agencies and regular reviews, including in the energy and climate sector.

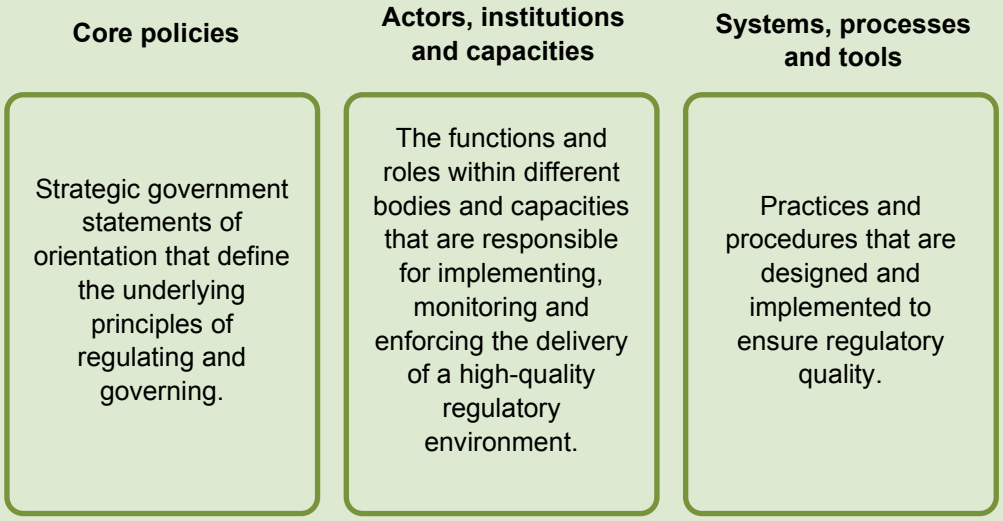
Efficient and effective regulators, with good regulatory management and governance practices, are needed to administer and enforce regulations, notably during the energy system transformation. The comprehensive regulatory reviews of individual policy areas carried out by governments frequently find that there is scope to enhance governance as part of broader initiatives to improve regulatory outcomes, notably for consumers and businesses.

The OECD Best Practice Principles for Regulatory Policy: The Governance of Regulators were developed in 2014 to assist countries in developing such a policy. The principles seek to construct an overarching framework to support initiatives to drive further performance improvements across regulatory systems in relation to national regulatory bodies or agencies (regulators). The best practices set out seven principles of good governance: 1) role clarity; 2) preventing undue influence and maintaining trust; 3) decision making and governing body structure for independent regulators; 4) accountability and transparency; 5) engagement; 6) funding; and 7) performance evaluation.

Achieving good regulatory outcomes is almost always a co-operative effort: by the government, among regulators, the regulated and the broader community. Governance arrangements for regulators can be important to foster such co-operative efforts and build the legitimacy of any necessary, strong enforcement action. For these reasons, governance arrangements require careful consideration to ensure they promote, rather than hinder, the efficient achievement of policy objectives and public confidence in the operations of regulatory agencies.

Good governance also requires that the government sets core policies through strategies and frameworks.

Figure 2.4 OECD Best Practice Principles for Regulatory Policy



Source: OECD (2014).

Climate and energy strategy and targets

The National Energy Transformation Partnership is Australia's integrated national energy and emissions agreement, as agreed by energy ministers in August 2022. The partnership will serve as an umbrella framework for the short-, medium- and long-term actions that all governments must take to optimise the energy sector's role in the national transformation to net zero.

The National Energy Transformation Partnership reflects a new era of collaboration across governments, and will deliver actions through a series of discrete work streams and working groups along the key themes of decarbonisation (introduction of an emissions objective in the National Energy Objective), energy governance, offshore renewable energy, generation and storage adequacy, co-ordinated gas and electricity planning, enhanced energy security management, and the implementation of nationally significant transmission projects. Several concrete co-designed strategies have been announced, including the development of a First Nations Clean Energy Strategy and the National Renewable Energy Supply Chain Action Plan.

Key priority actions for 2023 envisaged under the partnership are as follows:

- transforming Australia's energy system to align with net zero while providing more affordable, secure, and reliable energy to Australians, (including improving regulatory certainty and efficiency for, and accelerating delivery of, dispatchable renewable energy, storage and nationally significant transmission projects)
- efficiently and effectively contributing to the achievement of all Australian emissions reduction targets
- investing in Australia's adaptation and resilience to climate change

- empowering and comprehensively engaging with Australia's regions and remote communities, including First Nations, on the pathway to decarbonisation and Australia becoming a renewable energy superpower
- delivering a co-ordinated and strategic approach to achieving improvements in energy productivity across the economy.

In September 2022, Australia adopted the Climate Change Act 2022. The act legislates Australia's updated NDC, which targets GHG emissions reductions of 43% from 2005 levels by 2030 and net zero emissions by 2050. With the act, the Australian Government adopted overarching targets which embrace the ambitions of the states and territories with net zero goals and energy and climate targets (Table 2.2). The act requires an Annual Climate Change Statement, informed by the Climate Change Authority's advice to the minister on the future GHG emissions reduction targets and periodic implementation reviews. The first statement was issued in December 2022 (DCCEEW, 2022).

Table 2.1 Australia's national 2020, 2030 and 2050 energy and climate goals

		2020 and 2021 status	2020	2030	2050
GHG emissions	**GHG emissions versus 2005 (excluding removals)**	-20%	–	-43%	Net Zero
Energy productivity	**Real GDP/primary energy consumption**	+8.5%	–	+40%	–
Renewable energy	**Share of renewable generation capacity in electricity (GWh)**	40 000 or 30%	33 000	82%	–

Notes: GHG = greenhouse gas; GDP = gross domestic product; GWh = gigawatt hour.

The Australian Government put forward a plan to reach a share of 82% of renewable electricity by 2030 in the national energy mix across Australia.

The NEPP, adopted in 2015, set a goal of boosting Australia's energy productivity by 40% between 2015 and 2030. In 2019, energy ministers agreed to the Trajectory for Low Energy Buildings as a national plan to set a pathway towards zero energy-ready commercial and residential buildings in Australia. In 2022, the Australian Government consulted on the National Energy Performance Strategy, which will provide guidance across the government on the long-term vision for energy efficiency.

Table 2.2 Australian state and territory energy targets

State or territory	Net zero commitments	Emissions reduction targets	Renewable energy targets
Australian Capital Territory	Yes 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	Yes by 2050	50% by 2030 compared to 2005 levels	12 GW of renewable energy by 2030
Northern Territory	Yes by 2050	No interim targets	50% by 2030 70% renewable electricity for Indigenous Essential Services communities by 2030
Queensland	Yes by 2050	30% by 2030 compared to 2005 levels	50% by 2030 70% by 2032 80% by 2050
South Australia	Yes by 2050	50% by 2030 compared to 2005 levels	100% by 2030 500% by 2050
Tasmania	Yes by 2030	No interim targets	100% renewable electricity since 2020 150% by 2030 200% by 2040
Victoria	Yes 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	Yes 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: DCCEEW, (2022).

Energy market reforms and energy security

In electricity, the government is implementing measures to further boost the integration of variable renewable energy into the electricity system and to ensure adequate firming capacity is available in NEM jurisdictions, building on the lessons from the South Australia blackout in 2016 and the June 2022 energy market crisis.

Major reforms include adapting the NEM regulatory rules and system operation to higher shares of variable renewables towards the decarbonisation of electricity. The Australian Government aims to reach a share of 82% of renewable electricity in the national energy mix by 2030. Based on the EMM announcement of 12 August 2022, an emissions reduction goal will be included in the National Electricity Objective alongside security, competition and affordability objectives. The Australian Government is promoting major infrastructure investment with AUD 20 billion to "rewire the nation", a National Reconstruction Fund of AUD 15 billion and the Powering the Regions Fund of AUD 1.9 billion.

The government has implemented a series of gas market reforms to support affordable, reliable, secure gas supplies for domestic consumers. These include reforms for greater market transparency, transmission access and secure east coast gas supplies through the new Heads of Agreement (Australian Government and LNG exporters). A reform of the Australian Domestic Gas Security Mechanism was also announced in 2022. In October 2022, amendments to the National Gas Law were passed to extend the AEMO's functions and powers to manage reliability and gas supply adequacy for the east coast gas market over the winter of 2023 and beyond. Australia also extended both the National Gas Law and National Energy Retail Law to hydrogen and other renewable gases. The ACCC conducted regular price inquiries on gas and electricity markets, and rules of retail misconduct have been adopted to keep an average wholesale electricity price of 70 AUD/MWh and the domestic gas price below the LNG netback price.

As part of the market reforms and in the light of a cost-of-living crisis, energy affordability has been a strong driver of policy action. In December 2022, the Australian parliament passed legislation setting a domestic wholesale price cap of AUD 12 per GJ on natural gas for one year. New South Wales and Queensland Governments are taking action by effectively setting ceilings for the price of coal used for electricity generation to AUD 125 per tonne, with the Commonwealth to contribute to costs. The government presented an AUD 1.5 billion relief package for households and small businesses alongside financial assistance for the electrification of heating and cooking. Coal companies whose operating costs exceed that price limit will be compensated to ensure supply stability.

Concerning petroleum products, the Australian Government adopted a comprehensive fuel security package and undertook a Liquid Fuel Security Review in 2019. Its long-term fuel security goal is to increase Australia's domestic storage and hold a sovereign refining capability that meets Australia's needs during an emergency.

Energy security management is a major priority under the National Energy Transformation Partnership, and in particular cybersecurity, which will require an update of the Australian Energy Security Cyber Security Framework for proactively managing emerging energy system risks in areas such as climate resilience and cybersecurity of distributed energy

resources. At their December 2022 meeting, energy ministers endorsed a rule change request to confirm and clarify the AEMO's roles and responsibilities in cybersecurity.

Securing the social licence for energy infrastructure

The Australian Government supports public investments in major energy infrastructure projects, including NEM-wide interconnectors, dispatchable generation (Snowy 2.0 and the Hunter Power Plant) and storage as well as microgrids and clean energy generation at the local and community levels. Timely permitting and environmental and social approvals are critical for Australia's energy transition.

"Rewiring the Nation" is an agreement between the Commonwealth, Tasmanian and Victorian governments to deliver key projects, including Kerang Link (2028-2029), both Marinus Link cables (2031), North West Tasmanian Transmission Developments, Victorian offshore wind transmission and Tasmania's Battery of the Nation. In addition, states and territories are investing in major infrastructure plans. The NSW Electricity Infrastructure Roadmap includes plans for at least 12 GW of renewable energy and 2 GW of long-duration storage by 2030, alongside the construction of the Waratah Super Battery, the largest network battery in the southern hemisphere. The Queensland Energy and Jobs Plan includes an AUD 62 billion supergrid and 22 GW of additional renewables capacity by 2035, 7 GW of pumped hydro storage, the conversion of coal-fired power stations to clean energy hubs, including a jobs security guarantee. For "Rewiring the Nation", the Australian Government adopted AUD 20 billion funding package and committed AUD 9.4 million to design a new framework for nationally significant transmission projects, including the regulatory process in the NEM for the development of this critical infrastructure. A new Rewiring the Nation Office was created with the AEMO as a technical adviser and the CEFC as the bank.

The Rewiring the Nation Office will partner with the Australian Energy Infrastructure Commissioner and state, territory and local governments on new transmission projects and regulatory reforms and will focus on strengthening community engagement, social licence and benefit sharing for transmission. The Australian Energy Infrastructure Commissioner's mandate was extended on 26 March 2021 by the then-Minister for Energy and Emissions Reductions. The role and mandate built on the National Wind Farm Commissioner, created in November 2015. The current commissioner is Andrew Dyer, executive, chairman and company director, who serves on a number of boards and advisory boards and is a Professorial Fellow at Monash University.

Under the National Energy Transformation Partnership, energy ministers have outlined plans to work jointly on a First Nations Clean Energy Strategy. Placing First Nations communities at the heart of Australia's clean energy transition is part of a new strategy to share the benefits of clean energy investment across the nation, notably for Aboriginal and Torres Strait Islander people. The Australian Government is committed to the referendum to enshrine an Aboriginal and Torres Strait Islander Voice in the Constitution.

The Australian Government presented an AUD 5.5 million investment to kick-start and support the co-design process and strategy development, alongside an initial investment of AUD 83.8 million for microgrids in remote First Nations communities. This funding will leverage and build on the best practice work of jurisdictions, First Nations communities and organisations to shape the strategy, including identifying priority reforms and investment.

Box 2.2 International experience in faster permitting of energy infrastructure

Around the world there is a growing urgency of and commitment to faster approvals. In the context of the European energy crisis, the European Council adopted temporary emergency rules to accelerate the deployment of renewable energies like wind (repowering), solar PV and heat pumps (EC, 2022). Under the rules, renewable energy projects "would be presumed to be of overriding public interest," which will allow a "simplified assessment" to speed up procedures. The new rules clarify the scope of nature protection rules under the European Union's (EU) Birds and Habitats Directives to eliminate bottlenecks in the permit-granting process for renewable energy projects.

Canada modernised its environmental and regulatory approval regimes in 2019. Bill C-69 of 2019 replaced the National Energy Board Act with the Canadian Energy Regulator Act*. Bill C-69 also helped to streamline Canada's environmental and regulatory system by modernising the Canadian Environmental Assessment Agency through the creation of the Impact Assessment Agency of Canada, which reports to the Minister of Environment and Climate Change. Bill C-69 set out responsibilities for both the Canadian Energy Regulator and the Impact Assessment Agency to consult and accommodate, when required, during the three-year process indigenous peoples, provinces and territories, companies, environmental groups, and the public. The new impact assessment system includes a more inclusive participation process, provides clear expectations and shorter legislated timelines, and aims to avoid duplication with other jurisdictions wherever possible with a "one project, one review" approach.

* The Canadian Energy Regulator regulates pipelines, power lines and offshore renewable energy projects; provides oversight of oil and gas exploration and activities on frontier lands and offshore; approves the export and import of natural gas and the export of oil; and provides energy statistics, analysis and information.

Diversifying Australia's economy

Australia's economy relies on the natural resource base of fossil fuels and critical minerals. The country is one of the largest energy exporters in the world, and the leading coking coal and LNG exporter. Australia produces a breadth of renewable energy, critical minerals, including lithium, of which it is the world's largest producer, and cobalt and rare earth minerals. Australia has the stated ambition to become a renewable energy, critical minerals and hydrogen exporter.

At the federal level, energy taxation and rates are not in line with sustainable or efficient energy consumption (see Chapter 3) and are not reflective of carbon content. The Australian Government levies fuel excise and duties at various rates, based on energy content. Australia applies a fuel excise on transport fuels (including aviation) and residential and commercial heating. Petrol and diesel are indexed twice a year in line with the consumer price index and are taxed at AUD 0.433 per litre as of August 2021. The Goods and Services Tax applies to the excise-inclusive price of petrol and diesel at a single uniform rate of 10%. The Goods and Services Tax also applies to biofuels and gaseous fuels.

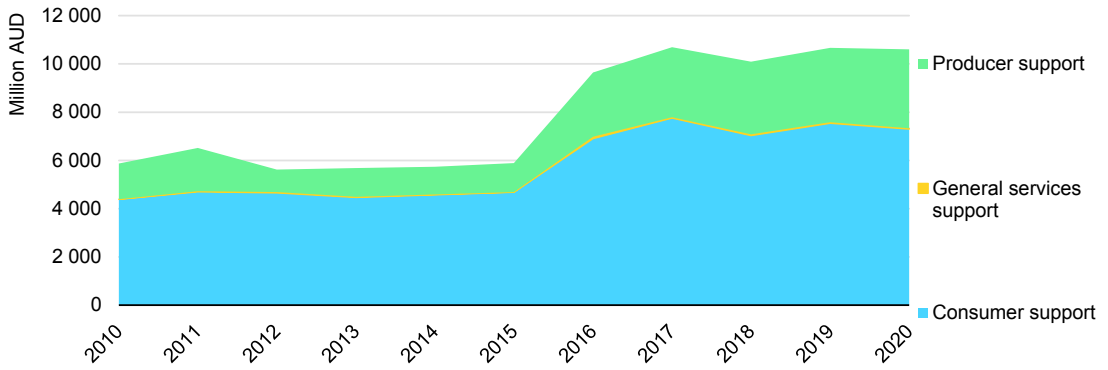
Fuel tax credits are applied to heavy vehicles for gasoline and diesel and heavy oil use in industry and electricity fuels. Fuel tax credits provide businesses with a rebate of the tax embedded in the price of fuel. In 2020-2021, fuel tax revenue was AUD 19.78 billion and businesses claimed AUD 7.6 billion of fuel tax credits, net of road user charges. This is counted as an indirect fossil fuel subsidy by the OECD, as shown in Figures 2.5 and 2.6.

Table 2.3 Indirect government support to fossil fuels in Australia, in billion AUD, 2015-2020

	2015	2016	2017	2018	2019	2020
Tax expenditures	9.313	9.236	8.015	7.883	7.937	7.175
Direct transfers	1.031	0.827	0.579	1.47	2.176	1.847
Total	10.344	10.063	8.594	9.353	10.113	9.022

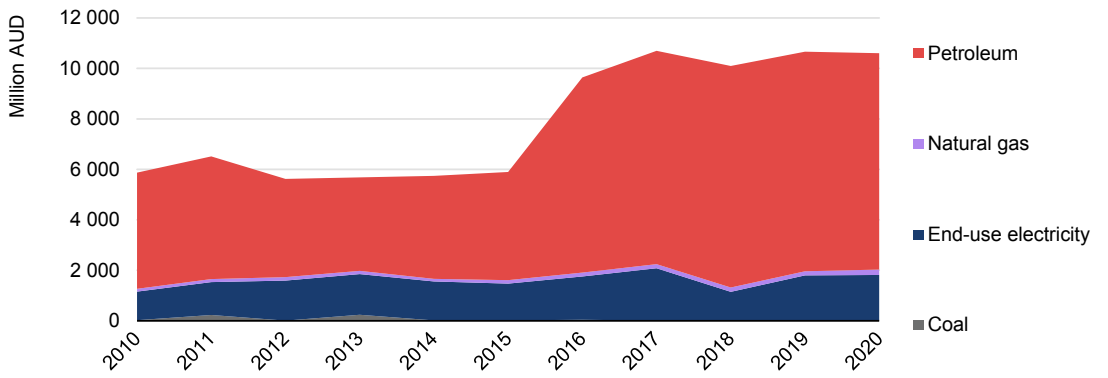
Source: OECD, (2021).

Figure 2.5 Australia's fossil fuel support by beneficiary, 2010-2020



Source: OECD, (2021).

Figure 2.6 Australia's fossil fuel subsidy by fuel type, 2010-2020



Source: OECD, (2021).

Australia's LNG export earnings are forecast to rise from an estimated AUD 70 billion in 2021-2022 to AUD 90 billion in 2022-2023, driven by rising global energy and commodity prices. The Petroleum Resource Rent Tax (PRRT) revenue also increased,

from AUD 897 million in 2020-2021 to AUD 2.17 billion in 2021-2022. The PRRT is levied on the profits from petroleum projects in offshore petroleum production in Australian waters at a rate of 40%.

To support the shift towards diversified and environmentally sustainable government spending, Australia can also learn from other countries that are scrutinising public spending with the aim of boosting "green budgeting". France was the first country to conduct a first assessment of the environmental impact of the 2021 Budget Bill, by using the six criteria of the EU Taxonomy Regulation: 1) climate change mitigation; 2) climate change adaptation; 3) sustainable use and protection of water and marine resources; 4) the transition to a circular economy; 5) pollution prevention and control; and 6) the protection and restoration of biodiversity and ecosystems.

The abundance of domestic renewable and non-renewable energy resources, along with a diverse wealth of critical minerals, presents Australia with a clear opportunity for a secure energy transition to a net zero emissions economy while continuing to perform a key role in international energy markets as a reliable trading partner. The Australian Government has the stated objective of making Australia a superpower for exports of renewable energy and critical minerals. Australia expects major supply chain bottlenecks for wind and solar power materials and transmission cables. The Supply Chain Resilience Initiative and the Sovereign Manufacturing Capability Plan aim to support efforts in this direction (see Chapter 11).

Towards a people-centred strategy

A number of initiatives are underway to support workers throughout the energy transition.

The Australian Government has committed AUD 12.9 million to the priority of *Jobs and Skills Australia* to help tackle skill shortages and plan for the workforce of the future. A new Clean Energy Capacity study will be a high priority for Jobs and Skills Australia. The study will provide evidence and insights to support workforce planning, and inform skills development needs and training for Australia's clean energy sector.

The DCCEEW produces the Australian Energy Employment Report, a national workforce survey of businesses and organisations in, or supporting, the Australian energy sector. This will give federal, state and local governments insights to assist in the development of policies regarding jobs, skills development and training opportunities.

Both initiatives will support the development of a National Energy Workforce Strategy, which will provide a comprehensive national approach to ensure Australia's future energy system has a pipeline of highly skilled and diverse workers to support the energy transition.

Australia joined the Equality in Energy Transitions Initiative in May 2018. At COP26 in November 2021, it announced it had joined the Equal by 30 campaign as a public commitment to work towards equal pay**,** equal leadership and equal opportunities for women in the clean energy sector by 2030. The Australian Government has endorsed the campaign's four key public sector principles and is developing tailored commitments outlining the concrete action to accelerate the participation of women in the clean energy sector.

In 2021, the IEA Global Commission on People-Centred Clean Energy Transitions adopted a set of actionable recommendations for governments, industry and citizens by drawing on recent experiences and best practices from around the world (Figure 2.7).

Figure 2.7 Principles for just energy transitions

DECENT JOBS AND WORKER PROTECTION

1. Design transitions to maximise the creation of decent jobs
2. Develop tailored government support for communities and workers as well as focus on skills and training
3. Use social dialogue, robust stakeholder and policy co-ordination to deliver better outcomes

SOCIAL AND ECONOMIC DEVELOPMENT

4. Ensure that policies enhance social and economic development, and improve quality of life for all
5. Prioritise universal clean energy access and the elimination of energy poverty
6. Maintain and enhance energy security, affordability and resilience

EQUITY, SOCIAL INCLUSION AND FAIRNESS

7. Incorporate gender, equality and social inclusion considerations in all policies
8. Ensure fair distribution of clean energy benefits and avoid the risk of disproportionate negative impacts on vulnerable populations
9. Integrate the voices of younger generations in decision making

PEOPLE AS ACTIVE PARTICIPANTS

10. Involve the public through participation and communication
11. Use insights from behavioural science to design effective behaviour change policies
12. Enhance impact through international collaboration and exchange best practice

Source: IEA, (2021).

International experience can inform Australia's strategy. The United Kingdom has created the green jobs task force which is completing a survey of jobs/skills to understand sectoral requirements relative to new opportunities. European countries have adopted just energy transition strategies with dedicated funding arrangements. For instance, Spain has initiated Just Transition agreements between government, companies and labour, while the EU Just Transition Fund is a financial instrument to help European Union member governments address asymmetric job shifts, particularly in coal mining regions, through long-term support mechanisms. The German government established a multi-stakeholder Commission on Growth, Structural Change and Employment, which made recommendations on the timing and pace of the coal phase-out as well as transitional assistance to affected communities. The United States has recently introduced new geothermal tax credits under the Inflation Reduction Act focused on energy communities (defined as those that have typically depended on coal/fossil fuels for economic activity).

Energy data strategy for tracking the energy transition

Regarding the energy portfolio, the Australian Government has seen frequent institutional changes that have had implications for energy and climate data collection and monitoring. The DCCEEW was created in 2022. With its energy and climate portfolio, this is an opportunity for setting up data requirements for Australia's transition. The Department of Industry, Science and Resources maintains oversight of upstream development, mining and critical minerals and hosts the Office of the Chief Economist. The DCCEEW is responsible for the Australian Energy Statistics, the government's official source of energy statistics forming the basis of Australia's international reporting obligations, including those to the IEA. The data set is updated annually and consists of historical statistics on energy production, trade and consumption.

The energy data landscape includes multiple agencies collecting and publishing energy data, sometimes subject to competing priorities. The main source is the National Greenhouse and Energy Reporting Scheme (NGERS) data collected by the Clean Energy Regulator under the National Greenhouse and Energy Reporting Act 2007. It covers reporting at the facility level from companies above a certain threshold based on a financial year ending in June. Data-sharing operations with NGERS are very successful. Other sources include: the Australian Petroleum Statistics Survey; the Department of Industry, Science and Resources and National Offshore Petroleum Titles Administrator; the Australian Bureau of Statistics; the Bureau of Infrastructure, Transport and Regional Economics; the AEMO; the Australian Energy Regulator; state government data sets; own estimates; and modelling.

With regard to energy demand by sector, the government has mandatory data reporting only from large users in manufacturing and mining (above a threshold of 25 000 tonnes), based on the NGERS. Data for small to medium-sized users are estimated; data for transport are derived from Australian petroleum statistics and activity data from the Bureau of Infrastructure, Transport and Regional Economics; data for the residential and commercial sectors are derived from utilities regulator data combined with data, studies and analysis from other sources, such as the Residential Baseline Study.

Several initiatives to improve data have been introduced and are ongoing: a new data strategy on governance to reduce barriers to data sharing across jurisdictions and organisations (Energy Security Board Data Strategy); a new data platform to improve data accessibility and use with a focus on energy and emissions data (Data Management and Analytics Platform); a partnership between the Commonwealth, CSIRO and the AEMO to enable data science to be used to support improved operation and planning of the energy system (National Energy Analytics Research Program); improvements to sectoral estimates (for example using for the first time actual electricity and gas consumption for the residential sector from the utilities regulator); and automation to reduce human error in data compilation and validation. The IEA also praises the recent efforts to submit updated and improved energy technology RD&D data.

Data on energy prices and household expenditure remain incomplete, as the official data from the Australian Bureau of Statistics excludes "electricity, gas and other fuels". Australia does not submit natural gas prices for households (40% of residential energy consumption); nor quarterly electricity prices (56% of households' energy consumption); nor fuel oil, light fuel oil, coal, natural gas for all users and electricity; nor diesel and liquefied petroleum gas prices for industrial users.

With regard to oil and gas data, the government legislated a mandatory reporting programme for petroleum sector data which is collected and managed by the DCCEEW and informs the Australian Petroleum Statistics. This mandatory programme replaced the voluntary survey conducted to collect monthly petroleum data from 1 January 2018 onwards. The DCCEEW collects data and publishes comprehensive statistics on oil supply and use in Australia via the department's official Australian Petroleum Statistics monthly publication.

The bulk of the data comes from the department's own data collection, which has, since 2018, been underpinned by legislation (the Petroleum and Other Fuels Reporting [POFR] Act 2017), which makes it mandatory for companies to provide the data to the government. The department also receives data from other sources, mainly through data-sharing arrangements with other government departments that collect information from both survey-based and administrative data sets. Under the POFR Act, activities such as producing, refining, wholesaling and holding stocks of oil products (such as crude oil, liquefied petroleum gas, petrol, diesel, bitumen and lubricants) and alternative transport fuels (such as biofuel) must be reported. The IEA commends the introduction of the mandatory reporting, which ensures reliable and accurate monthly oil data. A review of the POFR Act is ongoing, with the objective of potentially covering more products/flows.

Since 2021, the department has enhanced its internal data management capabilities (called the Petroleum Statistics Information Management System), supporting a more automated and integrated data management system (the online submission portal "Liquid Fuels Gateway" for companies) and is modernising its data dissemination with a new interactive dashboard.

Reporting of natural gas data (on a monthly basis) remains incomplete (observed domestic consumption and stocks levels are not transmitted) and trade data by country of destination cannot be reported due to confidentiality issues. Natural gas data are collected on a voluntary basis (only LNG is a covered product under the POFR Act, while ordinary natural gas is not a mandatory item) and would benefit from future inclusion in a mandatory data collection system.

With regard to monthly electricity reporting to the IEA (MES), Australia previously only reported generation from large-scale solar PV plants and grid-connected generation, which does not fully represent the country's power system. The government confirmed that data from another source are available for small-scale solar PV and has included this in the IEA MES since February 2022. However, monthly data is not available to report off-grid generation.

Assessment

Australia is an important energy producer of coal, gas and critical minerals needed for the global economy, which is important factor for its energy transition. In 2021, Australia's energy production – mainly of coal and natural gas – was more than three times higher than the country's total energy supply. TES is strongly dominated by fossil fuels, covering 92% of the total in 2021, the highest in the IEA. Australia is the fourth-largest coal producer in the world, after China, India and the United States. Since 2015, Australia has significantly increased its production of natural gas, exported in the form of liquid natural gas (LNG). Conversely, solar PV has become the leading source of renewable energy and, together with wind, has met all the incremental electricity demand over the past

decade. Australia has the highest share of rooftop solar per capita in the world, which features on more than one in three Australian homes.

With strong economic growth over decades, total final consumption has been increasing in Australia, with oil accounting for more than half of TFC in 2021, followed by electricity (24%) and natural gas (16%). The share of electricity is around the IEA average (23%), with relatively high electrification in buildings and relatively low electrification in transport. In terms of sectors, industry accounts for the largest share of energy consumption (39%), closely followed by transport (38%) and buildings (23%). Australia has decoupled energy demand from both GDP and population growth.

Since the IEA's last review of Australia in 2018, the government has stepped up its climate ambition at the Commonwealth level, aligning to the net zero ambitions of the states and territories and is taking an inclusive and collaborative approach to energy policy under the new National Energy Transformation Partnership.

Energy and climate policy is a competency of the state and territory governments in Australia. Co-ordination is important for the national wholesale and retail electricity and gas markets. The Energy Ministers Meetings (EMM) established under the National Cabinet with six working groups can enable energy policy co-ordination between these levels of government. Collaboration is now structured under the new National Energy Transformation Partnership, an integrated climate and energy emissions agreement.

The Australian Government increased its climate ambition with a new target of a 43% reduction of GHG emissions by 2030 from 2005 levels, an increase from the previous government's target of 26-28%. The government also legislated its new 2030 target alongside the net zero ambition by 2050 in the Climate Change Act 2022. As part of the Annual Climate Change Statement, the government must review progress on Australia's energy transition.

Energy efficiency goals and policies were set out in the NEPP, which established a target to increase energy productivity (GDP/TES) by 40% between 2015 and 2030. At their October 2022 EMM, demand-side action and energy efficiency were prioritised and new national rules proposed, notably the introduction of fuel economy standards, the new National Construction Code and energy performance in buildings. A new National Energy Performance Strategy is now under consultation and will refocus the government's strategy towards the energy demand side.

The creation of the DCCEEW in July 2022 will be fundamental to ensure greater coherence of energy and climate data for policy making at the Commonwealth level. The upstream and critical minerals sectors remain the purview of the Department of Industry, Science and Resources.

The new set-up will require more collaboration across departments to consolidate energy and climate data. This is particularly important in the context of liquid fuels security and progressing Australia's energy transition, which requires the collection and analysis of data for the design, implementation and tracking progress on energy, resources and emissions-related policies and programmes for the government. There are not sufficient data available on sectoral end-use and pricing for policy making. The government needs to increase the availability of policy-relevant energy information and seek cost-effective actions to enhance the data granularity on the demand side for energy prices across all

fuels, while integrating new fuels and technologies (hydrogen) in data collection and legislation and making use of data science.

A further challenge in the Australian energy system is the array of energy agencies and regulators, particularly in the NEM, of various jurisdictions and competency areas, which will also require co-ordinated action to achieve renewable energy and climate targets. The National Energy Transformation Partnership is a strong engagement platform and announced plans to streamline governance. This could also include a greater streamlining of the regulatory bodies, for instance, by creating a new Energy Sector Transformation Commission.

The social acceptance to construct and operate the necessary infrastructure to achieve Australia's net zero ambition will have to be secured. The IEA is impressed with Australia's Energy Infrastructure Commissioner, who is carrying out critical work towards improving public acceptance and making progress on major infrastructure projects on the ground. The benefits for local communities are significant and should be communicated as such.

It is commendable that the new partnership reflects the opportunities for consumers, critical energy market reforms, technology development, manufacturing in Australia, job creation, and the needs for a just and inclusive energy transition. There is a growing shortage of people with the training and skills required to support the transition. The forthcoming National Energy Workforce Strategy should reflect on opportunities to reskill labour from fossil fuel industries to transfer their skills to sustainable industries.

Key recommendations

The government of Australia should:

- Develop the social licence with citizens, consumers and communities for essential infrastructure in the energy and critical mineral sectors through community engagement. Ensure the Office of the Australian Energy Infrastructure Commissioner is fully resourced to support communities and project developers.
- As part of the National Electricity Market reforms, streamline the regulatory landscape of the NEM in line with OECD principles for good regulation, particularly role clarity, independence, transparency and accountability.
- Mainstream a people-centred transition approach with an evaluation of the jobs and growth impacts from an inclusive and just transition of communities and workers in support of the diversification of Australia's economy away from fossil fuel use and extraction.
- Track Australia's energy transition by designing an appropriately resourced national energy and climate information system. The system should include end-use energy and energy prices and expenditure data, a national energy forecast, and market data function. Strengthen data governance, remove institutional and legislative barriers to data sharing, and enlarge the scope of mandatory data reporting to natural gas and other fuels, including hydrogen.

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3. Energy sector response to climate change

Key data

GHG emissions with LULUCF (2020)*: 487.6 Mt CO_2-eq; -20% since 2005, -22% since 2005

GHG emissions without LULUCF (2020)*: 527.7 Mt CO_2-eq; +1% since 2005, +24% since 1990

CO_2 emissions from fuel combustion (2021): 360.9 Mt CO_2-eq; -1% since 2005

CO_2 emissions by sector (2021): electricity generation 47.6%, transport 24.3%, industry 24.3%, buildings 3.8%

CO_2 intensity per GDP (2021)**: 0.302 kg CO_2/USD (IEA average 0.186 kg CO_2/USD)

CO_2 intensity per capita (2021): 14.7 t CO_2/capita (IEA average 8.28 t CO_2/capita)

* Land use, land-use change and forestry

** Gross domestic product in 2015 prices and purchasing power parity (PPP).

Overview

From 1990 to 2020, Australia's total GHG emissions excluding land use, land-use change, and forestry (LULUCF) increased by 24%, from 426 million tonnes of CO_2 equivalent (Mt CO_2-eq) to 528 Mt CO_2-eq (Figure 3.1). Taking LULUCF into account, GHG emissions have decreased by 22% since 1990. LULUCF absorbed 40.2 Mt CO_2-eq in 2020. LULUCF was traditionally an emitting source, with 200 Mt CO_2-eq in 1990, but is a carbon sink since 2015. Increases in the LULUCF sink were driven by the decline in emissions from primary land clearing, forest cover expansion and a decline in the harvesting of native forests.

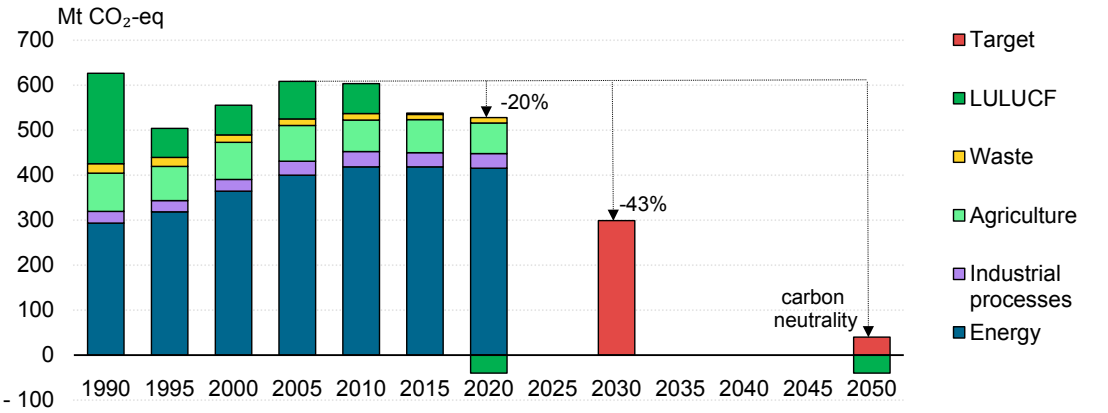
The energy sector plays a critical role in GHG emissions. In 2020, 79% of GHG emissions were energy-related, followed by agriculture (13%), industrial processes (6%) and waste (2%). Energy-related CO_2 emissions stem mainly from electricity and heat generation. GHG emissions from coal accounted for almost 50% of emissions. Oil and gas production is driving an increase in GHG emissions, notably in fugitive emissions, such as methane from mining and extraction, but also energy-related CO_2 emissions from LNG production.

In October 2022, the government joined the Global Methane Pledge alongside 130 signatories who collectively target a reduction in methane emissions by at least 30% by 2030 (from 2020 levels) across all sectors.

One of the first actions of the incoming government was to submit an updated NDC in June 2022. Aligning with the efforts of other advanced economies, the NDC strengthened

Australia's 2030 target to 43% below 2005 levels and reaffirmed its net zero emissions by 2050 target. In September 2022, the government passed the Climate Change Act, enshrining these targets into law. The pace of emissions reductions in Australia must double to reach these goals. The latest Australian Long-Term Emissions Reduction Plan was submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in 2021 and pre-dates the new NDC goal (DISER, 2021).

Figure 3.1 Greenhouse gas emissions by sector in Australia, 1990-2020 and 2030 and 2050 targets



Australia's GHG emissions mainly come from the energy sector. Despite a 20% decrease since 2005, the coming decade will require doubling the effort to reach a 43% decline.

Notes: Mt CO_2-eq = million tonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry.
Source: UNFCCC, (2022).

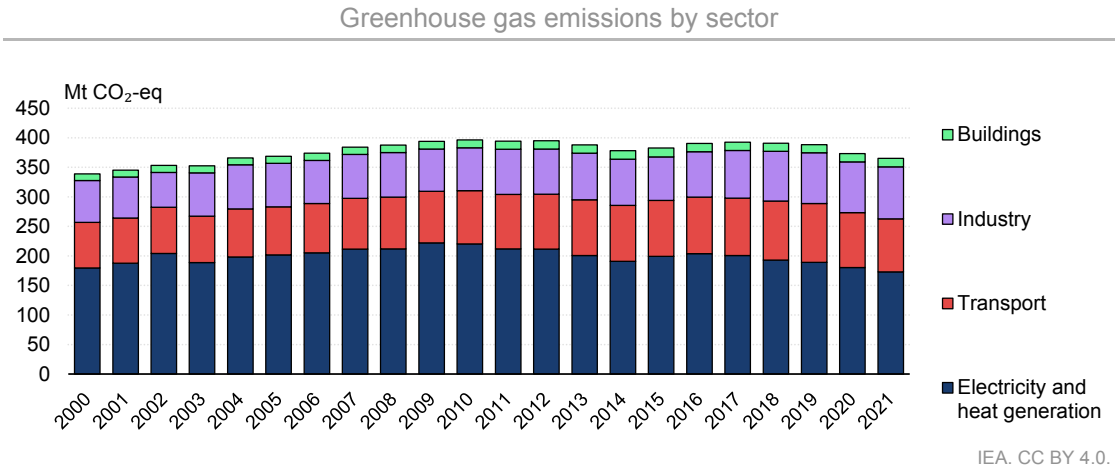
Energy-related greenhouse gas emissions

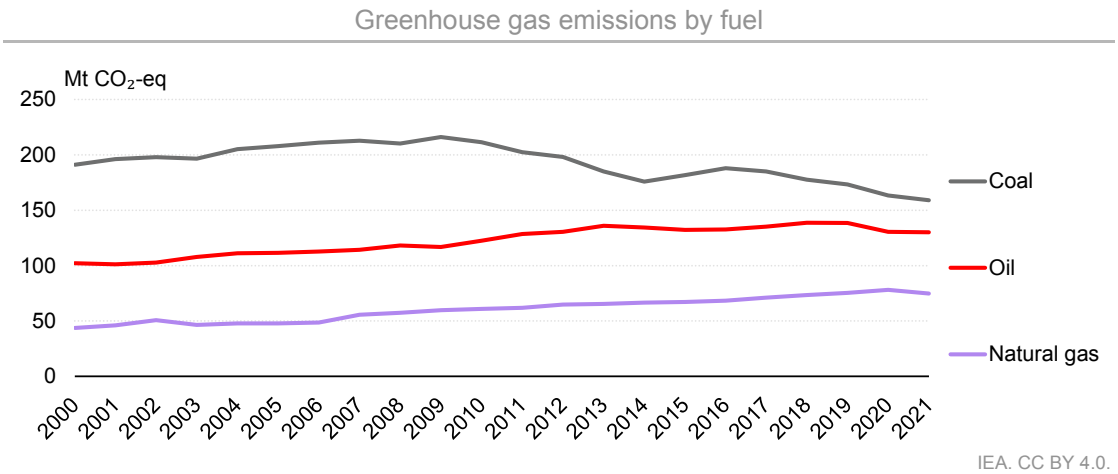
From 2000 to 2021, Australia's energy-related GHG emissions remained flat, fluctuating between a minimum of 338 Mt CO_2-eq in 2000 and a maximum of 393 Mt CO_2-eq in 2017 (Figure 3.2) and stood at 361 Mt CO_2-eq in 2021.

In 2021, electricity generation accounted for the largest share (47%) of energy-related GHG emissions, followed by transport (25%), industry (24%) and buildings (4%) (Figure 3.2).

Emissions from electricity generation decreased between 2010 and 2020, after a peak in 2016, as the use of coal in the power sector decreased. Conversely, emissions from transport and industry have slightly increased up to 2021.

Figure 3.2 Energy-related greenhouse gas emissions by sector and fuel in Australia, 2000-2021





Electricity generation covers half of emissions by sector. By fuel, coal is responsible for the largest part of emissions, but the total of coal emissions has come down in Australia.

Notes: Mt CO_2 = million tonnes of carbon dioxide; Mt CO_2-eq = million tonnes of carbon dioxide equivalent. Energy-related greenhouse gas emissions do not include fugitive emissions from fuels.

Source: IEA, (2022a).

Although Australia is the fourth-largest coal-producing country in the world, domestic GHG emissions from coal are decreasing, mainly in power generation.

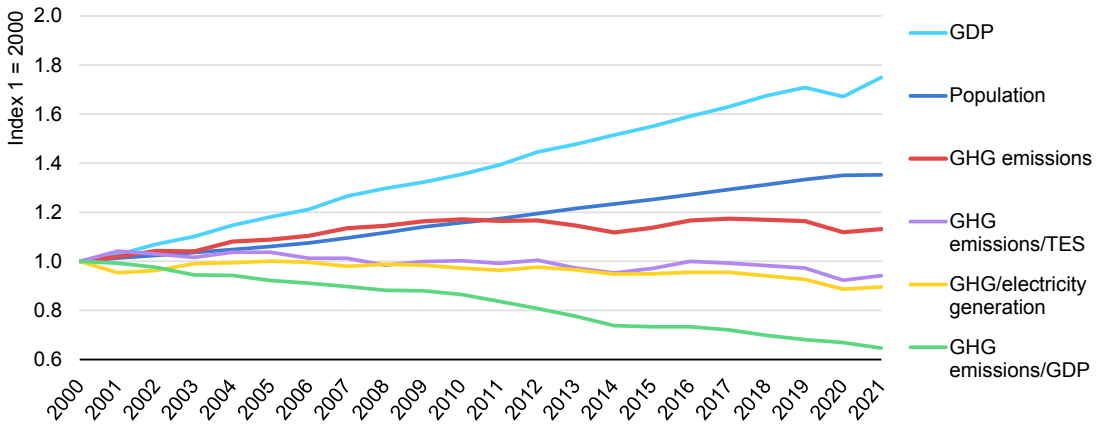
Almost half of GHG are emitted from coal (44%). GHG emissions from oil constantly increased from 122 Mt CO_2-eq in 2010 to 139 Mt CO_2-eq in 2019, driven by rising energy consumption in the transport sector. They then dropped in the next two years to 130 Mt CO_2-eq in 2021, following transport disruptions due to the Covid-19 pandemic.

Emissions from natural gas use rose by more than 30% from 2010 to 2021 due to its increasing role in electricity generation. GHG emissions from natural gas accounted for 75 Mt CO_2-eq in 2021.

Emission drivers and carbon intensity

Australia's GDP saw uninterrupted growth for two decades, increasing by 71% between 2000 and 2019. In 2020, GDP slightly declined by 2% due to the Covid-19 pandemic but recovered in 2021 (Figure 3.3). Meanwhile, the country's population increased by 35% between 2000 and 2021. Despite the increase in GDP and population, GHG emissions have been relatively stable, leading to a 35% decrease in the emissions intensity of the economy (GHG emissions/GDP) from 2000 to 2021. Over the same period, the country's emissions intensity of energy supply decreased by 9% and that of electricity generation fell by 10%.

Figure 3.3 Energy-related greenhouse gas emissions and main drivers in Australia, 2000-2021



Australia's energy-related GHG emissions are largely decoupled from economic growth but not yet from electricity generation or total energy supply.

Notes: GDP = gross domestic product; GHG = greenhouse gas; TES = total energy supply.
Source: IEA, (2022a).

Australia's energy exports and climate change

Australia is a net exporter of energy commodities (coal, LNG and others), and in 2021, 41% of its GHG emissions arose from export-oriented sectors[1]. For the period up to March 2022, Australia's territorial emissions (485 Mt CO_2-eq) were higher than its consumption-based emissions (419 Mt CO_2-eq). Emissions associated with the production of exports were 208.6 Mt CO_2-eq and those related to consumption of imports 141.1 Mt CO_2-eq. Consumption-based per capita emissions were 16 t CO_2-eq, significantly higher than the world average (4.5 t CO_2-eq) and other advanced economies, for instance, the European Union (8.6 t CO_2-eq).

[1] National Inventory Report data were accessed via the online Australian Greenhouse Emissions Information System. For consumption/production inventory breakdowns, data tables from the March 2022 quarterly update of Australia's National Greenhouse Gas Inventory were used. See: https://www.dcceew.gov.au/sites/default/files/documents/nggi-quarterly-update-march-2022.pdf.

Oil and gas production, mining, and exports have grown strongly in Australia. According to the government's latest data, in 2022, emissions released in Australia in export production were 208.6 Mt CO_2-eq, which is almost 50% more than for exports in 2004-05 (the base year of Australia's Paris Agreement target). Since 2005, Australia has reduced emissions by 41% from its domestic-facing sectors, while those from its export-facing sectors have risen by 47%, according to the latest data (DCCEEW, 2021).

In October 2022, Australia joined the Global Methane Pledge[2] alongside 130 signatories who collectively committed to cut methane emissions by 30% by 2030 from 2020 levels across all sectors. In the 2022-2023 Budget, the government allocated funding for developing technology and innovation in agriculture to address methane emissions. In the energy sector, the government aims at capturing waste methane to generate electricity, capturing or avoiding fugitive emissions from coal mines and gas infrastructure.

Reforms to the Safeguard Mechanism are planned to incentivise the industry sector to reduce emissions, including reductions of methane emissions from industrial and resource activities. Globally, many signatories of the Global Methane Pledge are now developing national action plans with actions and targets to reduce methane emissions from fossil fuel operations. This includes limiting leaks and flaring in the oil and gas industry, reducing coal mine methane emissions, and increasing measurement-based monitoring.

Climate targets

Consistent with the requirements of the Paris Agreement, Australia's emissions reduction targets are economy-wide, as in many UNFCCC parties. With the Climate Change Act 2022, the Australian Government legislated an increased commitment to reduce GHG emissions by 43% by 2030, compared to 2005 levels, and net zero emissions by 2050. The 43% reduction target translates into a 50% reduction by 2030 from 1990 levels.

The Climate Change (Consequential Amendments) Act 2022 changed 14 other acts to focus government institutions on achieving those targets, including the Northern Australia Infrastructure Facility, Export Finance Australia, the Australian Renewable Energy Agency, the Clean Energy Finance Corporation, the Clean Energy Regulator, CSIRO and Infrastructure Australia.

This more ambitious emissions reduction target of -43% has strong cross-party support and compares with other advanced economies' targets, including 55% in the European Union, 40% in Korea below 2018 levels, 40-45% in Canada below 2005 levels, 46-50% in Japan below 2013 levels and 50-52% in the United States from 2005 levels.

The Australian Government's 2022 Emissions Projections show that the country is on track to achieve a reduction of 32% below 2005 levels by 2030, which is considered the baseline scenario (DCCEEW 2022b), as reflected in Figure 3.4. This scenario builds on the announcements and goals from the Powering Australia plan, which was formalised through laws and budgets by end of 2022.

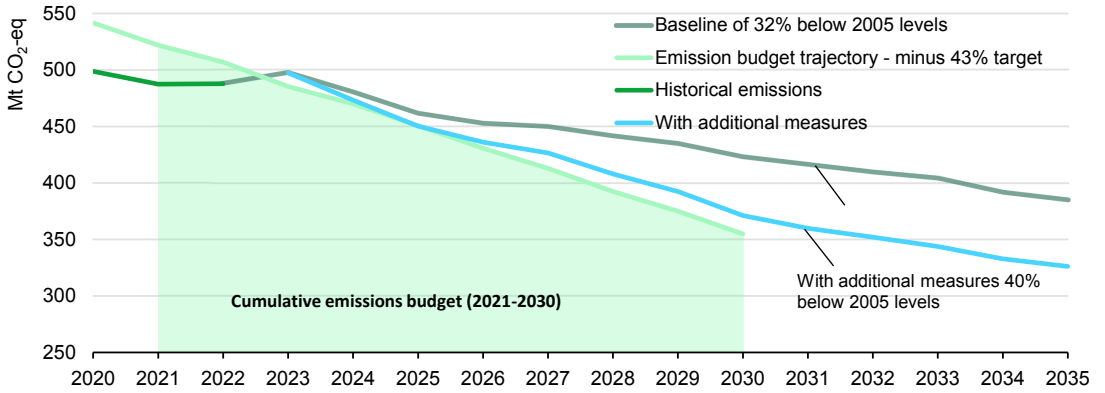
Additional efforts and policies are needed to meet the new 43% reduction goal. The "with additional measures" scenario can achieve a 40% reduction in emissions on 2005 levels

[2] For more information, visit: https://www.globalmethanepledge.org.

by 2030. This scenario reflects the Safeguard Mechanism[3] reforms and the national 82% renewable electricity target, which are under consultation and design. Announced funding and policies, such as the Powering the Regions Fund, the National Electric Vehicle Strategy and the National Reconstruction Fund, are not yet included in this scenario.

According to the emissions projections, from 2020 to 2030, most of the decreases in emissions are projected to come from the electricity sector due to the strong uptake of renewables supported by national, state and territory policies. Emissions are projected to increase in the transport, agriculture and LULUCF sectors (DCCEEW, 2022b).

Figure 3.4 Historical and projected emissions reductions in Australia, 2020-2035



Note: Mt CO_2-e = million tonnes of carbon dioxide equivalent.
Source: DCCEEW, (2022b).

Under the Climate Change Act 2022, the Minister for Climate Change and Energy is required to present an Annual Statement to Parliament, having regard to the CCA's advice. The Annual Climate Change Statement to Parliament is the main mechanism for the Australian Government to outline its approach and progress towards reaching its 2030 and 2050 emissions targets. Based on advice from the CCA, the government's Climate Change Statement will track progress annually.

On 1 December 2022, the Australian Government presented the first Annual Climate Change Statement to Parliament (DCCEEW, 2022b), which included a government response to the CCA's recommendations.

The CCA has also proposed a methodology for assessing progress, under which it aims to establish and track indicators for economic development and the transformation to net zero and identify additional measures (CCA, 2022).

The Minister of Climate Change and Energy has accepted the CCA's advice to develop a new net zero by 2050 plan that sets expectations and the sequence for when, how and by how much emissions should be reduced across different sectors of the economy (CCA, 2022). This will allow the government to track progress, identify sectoral pathways and seize the economic opportunities from the transformation to net zero.

[3] The Safeguard Mechanism applies to facilities with scope one covered emissions of more than 100 000 t CO2-eq per year.

The Australian Treasury's climate modelling is being strengthened to develop the plan to reach net zero by 2050, including a 2035 target and priority policies to achieve it. By 2025, Australia will need to submit a new NDC and commit to a 2035 target.

Australian states and territories have had ambitious targets, including commitments to net zero (before 2019) (Table 3.1). Victoria, South Australia, the Australian Capital Territory and Tasmania have legislated net zero targets.

Table 3.1 Australia's state and territory emissions reduction targets (2005 base year)

	2030	2050
Queensland	-30%	Net zero (2017)
New South Wales	-50% by 2030	Net zero (2016)
Victoria	-45-50% by 2030	Net zero (2016)
South Australia	-50% by 2030	Net zero (2015)*
Australian Capital Territory**	-65-75% by 2030 (based on 1990 levels)	Net zero by 2045 (2018)
Tasmania	Net zero or lower by 2030 (achieved in 2013)	
Western Australia	Follows the federal government's targets	Net zero (2017)
Northern Territory	Will set interim targets	Net zero (2020)

* The South Australian Government's legislated 2050 target is expressed as 60% below 1990 levels.

** The Australian Capital Territory also has a 2025 target of 50-60% below 2005 levels and a 2040 target of 90-95% below 2005 levels (Climate Change and Greenhouse Gas Reduction (Interim Targets) Determination 2018 (ACT)).

Source: ClimateWorks Australia, (2021).

Box 3.1 International case studies – Denmark, the United Kingdom and Canada

Governments around the world are taking steps towards setting out governance frameworks for implementing net zero targets and for achieving progress towards near-term targets for 2030. The experience of Denmark, the United Kingdom and Canada can be instructive for Australia as it seeks to implement its National Energy Transformation Partnership, track progress and correct course over time.

The Danish Climate Act of 2020 legislates Denmark's legally binding climate policy framework with targets and an annual climate policy review cycle (the year wheel). The annual cycle from February to December consisting of a review of policies and advice by the Danish Council on Climate Change (February), the Climate Status and Outlook by the Danish Energy Agency (April), the annual climate programme presented by the

Minister for Climate, Energy and Utilities (September), alongside discussions of the Finance Act, which will be finalised in a parliamentary debate by December.

The United Kingdom's Climate Change Act commits the government to reduce GHG emissions by at least 100% of 1990 levels (net zero) by 2050. A plan to reduce economy-wide GHG emissions by at least 68% by 2030 (from 1990 levels) is based on a five-year carbon budget approach. Under the act, the Committee on Climate Change has been an independent advisory body since 2008 whose task is to advise the government and devolved administrations on emissions targets; monitor and report to the parliament on meeting targets and carbon budgets; and conduct independent analysis into climate change science, economics, and policy.

Building on the 2016 Pan-Canadian Canadian Framework on Clean Growth and Climate Change, the Net-Zero Emissions Accountability Act (Bill C-12, 2021) enshrines the goal of achieving net zero emissions by 2050 and established a legally binding process for the federal government to set emissions reduction targets at five-year intervals for the years 2030, 2035, 2040 and 2045. Under the Emissions Reduction Plan, Canada's 2030 trajectory includes sectoral pathways, which reflect where there is emissions reduction potential in key sectors to make additional progress. For the oil and gas sector, the government of Canada decided to cap and cut emissions at the pace and scale needed to achieve net zero by 2050. The details of how best to design and implement this cap are decided in close collaboration with industry, provinces, indigenous partners and civil society.

Under Bill C-12, the Canadian government is required to report to parliament with plans to reach the targets, interim progress reports on implementation and effectiveness, as well as final assessment reports on each target. The five-year plans allow for correcting course toward the 2050 target. The act establishes Canada's Nationally Determined Contribution under the Paris Agreement as the 2030 target and stipulates that Canada's emissions reduction plan for 2030 include an interim objective for 2026. The act also established an independent advisory body mandated to provide the Minister of Environment and Climate Change with advice on achieving net zero emissions by 2050. The Net Zero Advisory Body was launched in February 2021. It conducted a consultation process and carried out expert analysis around four key lines of inquiry: buildings, transport, oil and gas, and governance.

Sources: IEA, (2019; 2022b).

Climate mitigation policies and measures by sector

The Australian Government is strengthening existing mitigation policies and adopting new standards and measures to achieve the new 2030 emissions reduction target under the Powering Australia plan and related goals.

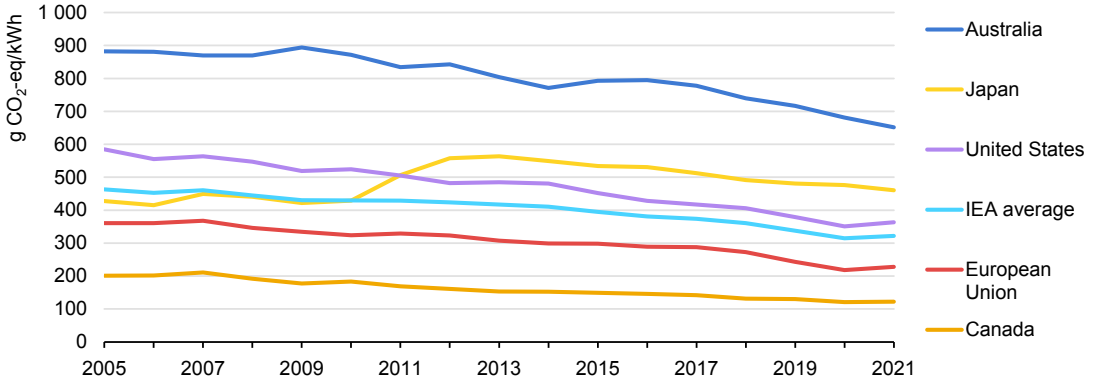
Australia's climate mitigation policies rely on its Carbon Crediting Scheme, formerly the Emissions Reduction Fund (ERF), the reformed Safeguard Mechanism alongside funding and tracking through Australia's clean energy agencies. The Climate Change Act of 2022

boosted the authority of the four institutions: ARENA, the CEFC, the CER and the CCA, which has been granted greater advisory functions. The 2022-2023 October Budget included AUD 47.1 million in funding over four years to restore the CCA's functions.

Power sector emissions mitigation policies

Australia's power sector accounted for almost half of the country's energy-related GHG emissions. And the power sector is at the heart of the country's energy transition, as the driver and enabler for emissions reductions in other sectors, such as transport and industry.

Figure 3.5 Greenhouse gas emissions intensity of electricity generation in Australia and selected countries, 2005-2021



Note: g CO_2-eq/kWh = grammes of carbon dioxide equivalent per kilowatt hour.

Source: IEA, (2022a).

The emissions intensity of power generation decreased by 23% between 2000 and 2020, according to IEA data, thanks to the Renewable Energy Target (RET) scheme, the rapid deployment of renewable energy, in particular, solar PV and changing power generation economics, which accelerated the closure of coal power plants. The trend is projected to continue and even accelerate. The AEMO's Integrated System Plan and its Step Change Scenario project an 83% share of renewables in the NEM by 2030.

In August 2022, the Australian Government, states' and territories' ministers jointly agreed to include an emissions reduction objective for the NEM under the National Energy Transformation Partnership. The Australian Government also announced a goal of reaching 82% of renewable energy in Australia's electricity generation by 2030.

Transport sector emissions mitigation policies

A quarter of Australia's energy-related GHG emissions stem from the transport sector, due to rising emissions from freight, domestic aviation and road transport activities from long-distance transport across the vast Australian continent.

Australia is beginning to develop policies and measures to promote low or zero emissions vehicles, low-emission fuels, transport sector efficiency and modal shifts. This includes considering the introduction of light vehicle fuel efficiency standards and the tightening of noxious emissions standards for heavy (Euro VI) and light vehicles (Euro 6d).

Under the Powering Australia plan, Australia has set a low emissions vehicle target for the federal government fleet of 75% of new purchases and leases by 2025 and is developing a National Electric Vehicle Strategy, which has completed consultation. The Australian Government will work with states, territories and industry to look at demand and supply-side measures to dramatically scale up electric vehicle (EV) uptake by 2030. The strategy will build on state-level targets and programmes and considers options for introducing fuel efficiency standards for light vehicles.

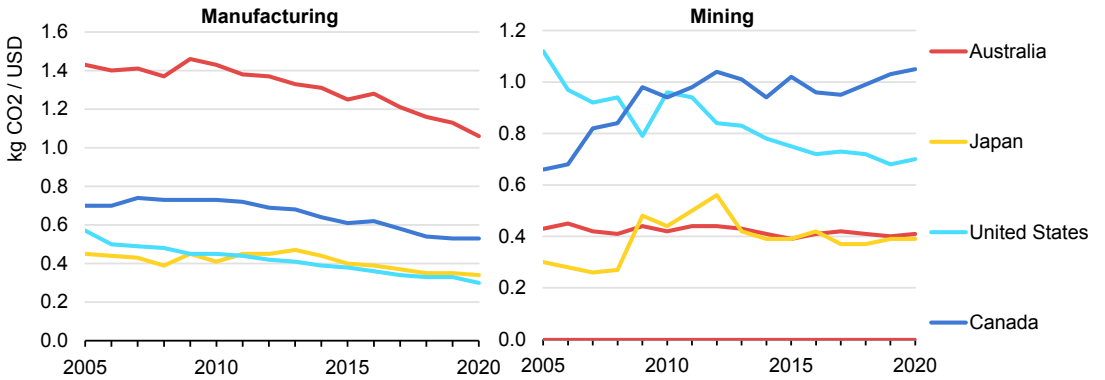
At the state level, New South Wales introduced a biofuel mandate in October 2007, while Queensland introduced biofuel mandates in January 2017 for the sale of bio-based petrol and bio-based diesel.

One of the priorities of the government's Aviation White Paper process is to maximise the aviation sector's contribution to achieving net zero carbon emissions, including through sustainable aviation fuel and emerging technologies. The Safeguard Mechanism also applies to the domestic transport sector, particularly aviation, rail and maritime transport.

Industrial emissions mitigation policies

Accounting for 23% of Australia's energy-related GHG emissions, the industry sector has been the key focus of climate mitigation policies. Australia's manufacturing industries have decreased their carbon intensity faster than other major economies, including Canada, Japan and the United States. Mining emissions sector trends have remained fairly stable.

Figure 3.6 Carbon intensity of manufacturing and mining industry sectors per value added in Australia, 2005-2020



Note: kg CO_2-eq/USD = kilogrammes of carbon dioxide equivalent per US dollar.
Source: IEA, (2022a).

Australia's carbon crediting scheme (ACCS, formerly the ERF) is a voluntary scheme to credit domestic reductions in GHG emissions. The Australian Government purchases Australian Carbon Credit Units (ACCUs) through the CER from eligible offset projects ("carrot"). The Safeguard Mechanism complements the scheme to ensure that large facilities keep their emissions below baselines set by the CER ("stick"). A facility's annual emissions must exceed the 100 000 t CO_2-eq threshold to be covered by the Safeguard Mechanism.

Over time, the scheme has expanded auctions and carbon credit opportunities in industry. In October 2021, the government announced its annual set of priorities for method

development in 2022: 1) transport, including emissions reductions created by EV and hydrogen refuelling infrastructure; 2) hydrogen – including injection of clean hydrogen into the gas network and the use of hydrogen in electricity generation or other uses, such as low-carbon steel; and 3) carbon capture, use and storage (CCUS, or carbon recycling), including in the production of industrial and building materials (e.g. concrete). Despite the methodologies available, most ACCUs have been generated in the agricultural sector to date. However, the scheme has not achieved substantial reductions in industrial emissions, with relatively limited uptake of carbon crediting projects in the industrial sector.

The CER issues ACCUs to eligible projects as abatement is realised. It also develops methodology determinations (or methods), which are rules for emissions reduction or carbon storage projects in the form of legislative instruments. The methods are reviewed by the independent Emissions Reduction Assurance Committee against legislated Offsets Integrity Standards and cannot be made if the committee finds that they do not meet the Offsets Integrity Standards. Among other things, offsets must have environmental integrity and the abatement represented by ACCUs must be "real" and "additional".

Following concerns raised about the lack of integrity of ACCU offsets, in June 2022, the Australian Government commissioned an independent review of the country's carbon credit system led by former chief scientist Professor Ian Chubb. The final review report will be presented by Minister Bowen in early 2023.

Australia is reforming the Safeguard Mechanism, which requires Australia's largest industrial GHG emitters to keep their net emissions below an emissions limit called a "baseline". Through these reforms, baselines will be reduced in a predictable and gradual manner to contribute to Australia's 2030 target and align with a trajectory to net zero. In 2022, the Australian Government presented for consultation options for the reform by:

- gradually reducing baselines to help Australia reach net zero emissions by 2050
- introducing credits for facilities that emit less than their baseline
- providing tailored treatment to emissions-intensive, trade-exposed facilities so businesses are not disadvantaged compared to international competitors and emissions do not increase overseas.

The safeguard crediting reforms were presented to parliament in November 2022.

Climate change adaptation

Extreme weather events such as bush fires, heat waves and flooding are becoming more and more frequent and devastating. In 2022, Australia had major floods in south-east Queensland, New South Wales and Victoria. The *State of the Climate Report 2022*, prepared jointly by CSIRO and the Bureau of Meteorology, confirms rising average temperatures, extreme heat, fire weather, drought, heavy rainfall events and coastal inundation in Australia (CSIRO/BOM, 2022).

The latest IEA climate resilience policy indicator of Australia shows that Australia's temperature is rising more quickly than the world average, even though some relatively cooler years do occur due to natural drivers such as La Niña and El Niño in the tropical Pacific Ocean and phases of the Indian Ocean Dipole that produce inherently high climate variability. The growing number of extremely warm days (which not only raises electricity demand but reduces electricity supply availability) places additional stress on Australia's energy systems. Overall, precipitation has declined, raising concerns about droughts and

wildfires, particularly in South Australia. Despite the trend towards increasing dryness, heavy rainfalls and tropical cyclones are also expected to become more intense due to global warming (IEA, 2022c).

Australia's National Disaster Risk Reduction Framework guides domestic efforts to reduce disaster risks. Launched in April 2019, the framework identified initial strategic outcomes over the five years from 2019 to 2023 to inform decision making across various sectors. The Australian Government National Adaptation Policy Office and the National Emergency Management Agency work closely together to co-ordinate and initiate stronger climate and natural disaster resilience across Australia. Climate resilience is a key focus of the Australian Government Disaster and Climate Resilience Reference Group. Created in 2015, it provides strategic guidance across the government and promotes resilience in the Australian Government's planning, policies and programmes.

The former Department of Industry, Science, Energy and Resources carried out the latest National Energy Security Assessment in 2021 to identify and mitigate potential energy security risks across electricity, gas and liquid fuels sectors. Climate change risks have been raised as an important factor by many stakeholders.

Extreme heat is considered one of the most significant stresses on Australia's energy systems since it affects energy demand and supply simultaneously. High temperatures not only spur cooling-load increases but can reduce electricity network capacity, decreasing thermal generation ratings and causing equipment failures. For instance, the combination of high electricity demand and lower electricity supply availability caused by extreme heat in South Australia and Victoria on 24-25 January 2019 prompted load shedding, which left 200 000 people without electricity.

Learning from the 2016 South Australia blackout, an Electricity Sector Climate Information Project was completed to calculate key climate risk variables that are relevant to the electricity grid, including projections up to 2100 (temperature, wind, rainfall, stream flows, solar radiation, fire weather). The AEMO uses information from the project to inform electricity system planning, including the Integrated System Plan. The Electricity Sector Climate Information Project also provides a foundation for Australian electricity and gas energy market participants to take into account climate change adaptation risks, both within their own business planning processes and through the General Power System Risk Review process. Data, reference material and case studies from the project have been made publicly available through the Climate Change in Australia (CCiA) website.

Under the Paris Agreement, Australia submitted a first Adaptation Communication to the UNFCCC in October 2021, which outlines retrospective domestic adaptation action and international adaptation support.

Roles and responsibilities for adaptation in Australia were agreed on by governments in 2012. Taking a shared responsibility approach, the agreement recognises the important, complementary and differentiated roles of all levels of government, businesses, households and the community in adapting to the impacts of climate change.

In 2021, the Australian Government released the National Climate Resilience and Adaptation Strategy 2021-2025, which set out how the former government planned to support adaptation across all levels of government, businesses and the community to better anticipate, manage and adapt to the impacts of climate change.

The strategy operates across four domains:

- natural domain: the landscapes, seascapes, ecosystems, agricultural lands, and diverse plant and animal life within Australia and its ocean territory
- built domain: surroundings, structures and infrastructure made using materials and human resources to facilitate life, health, work and play
- social domain: people, their communities, their culture, institutions, support systems and their interactions
- economic domain: the production and consumption of goods, productivity, financial systems, and the economy.

To enable more effective adaptation across Australia, the Australian Government aims to increase co-ordination, climate information and services; regularly assess progress; and improve actions over time.

State-level and sectoral schemes complement the National Climate Resilience and Adaptation Strategy, while federal government efforts to minimise disaster risks and reinforce the resilience of critical infrastructure also support the plan. Additionally, the federal government furnishes financial support and database development to supply high-quality climate information and tools to assess and manage climate change impacts.

Climate financing

As part of the 2015 Paris Agreement, the Australian Government pledged to spend a total of AUD 1.0 billion (USD 687 million) over five years in climate finance and climate resilience under its official development assistance (ODA). By 2020, Australia had provided AUD 1.4 billion (USD 963 million), overachieving its commitment (UNFCCC, 2020). In total volumes, Australia is among the large ODA donors of the OECD Development Assistance Committee, spending USD 613 million in 2020, or 26% of its total bilateral allocable ODA on climate-related financing[4].

A growing focus lies on supporting climate resilience in the Indo-Pacific region and Oceania, notably the Pacific Islands, through climate partnerships. In 2022, Australia and Pacific nations announced their bid to co-host the 2026 Conference of the Parties (COP).

In the run-up to COP26 in 2021, Australia pledged a total of AUD 2 billion (USD 1.4 billion) for climate financing. In the 2022-2023 Budget, the Australian Government expanded its investment in climate infrastructure through the Pacific Climate Infrastructure Financing Partnership to be implemented by the Australian Infrastructure Financing Facility for the Pacific. Out of a pledge of AUD 2 billion, AUD 700 million (USD 486 million) are dedicated to the Pacific and its specific and unique climate vulnerabilities and challenges. In 2021, DFAT created the Australian Climate Finance Partnership as a blended finance stand-alone, single-donor trust fund established jointly with and managed by the Asian Development Bank.

DFAT published the Climate Change Action Strategy (2020-2025), which helps DFAT to meet Australia's climate finance commitments.

[4] Workbook: OECD DAC Aid at a glance by donor (tableau.com)

Assessment

Action in the energy sector is critical for addressing climate change impacts, as it accounts for roughly 80% of Australia's GHG emissions. Australia's GHG emissions (including LULUCF) have flat over the past decades. Energy-related GHG emissions reached 361 Mt CO_2-eq in 2021, a 1% decrease from 2005. Electricity accounted for the largest share of energy-related GHG emissions, followed by transport, industry and buildings. In recent years, electricity sector emissions have decreased while those from the transport sector have increased. Australia is a net exporter of energy commodities, and in 2021, 41% of its GHG emissions arose from export-oriented sectors.

Since the IEA's last review of Australia in 2018, the Australian Government has stepped up its climate ambition and actions to implement it. In June 2022, Australia submitted an update of its 2021 NDC to the UNFCCC. To achieve net zero emissions by 2050, the government has pledged to double the effort for 2030 by targeting a 43% net emissions reduction from 2005 levels. Australia's commitment is reflected in the Climate Change Act, which was passed by the Australian parliament in September 2022 and legislated both the NDC and the net zero emissions by 2050 target. Thanks to the new targets, Australia caught up with the pace of emissions reductions pledged by other advanced economies and more closely aligns with a trajectory compatible with the Paris Agreement.

The government has yet to define a framework and policies under the Powering Australia plan for transitioning its economy and the energy sector to net zero emissions by 2050. The adoption of a net zero emissions by 2050 plan, as announced by the Minister of Climate Change and Energy, will enable the government to consult and assess the different pathways to net zero, thus reducing the considerable uncertainty on how the net zero target will be met in the energy sector through efficiency, renewables and other technology choices as well as the policies and measures needed. The government needs to adopt a whole-of-government approach to net zero. It has created an Australia wide working group on decarbonisation under the Energy and Climate Change Council, a cross-agency Net Zero Economy Taskforce in the Department of the Prime Minister and Cabinet to do so. Based on the modelling by the Treasury, the plan and annual climate change statements, the government should consider adopting sectoral emissions reduction targets, alongside interim emissions reduction milestones to 2030 and 2050.

Climate mitigation to achieve emissions reductions by 2030

Australia's 2022 emissions projections show that stated policies can achieve a reduction of 32% below 2005 levels (baseline). To move from 32% to 43%, additional measures will be critical to achieve the increased ambition for 2030 and get on track towards net zero emissions by 2050. The government announced its intention to strengthen existing policies, notably energy efficiency standards and the Safeguard Mechanism.

Energy efficiency policies are being strengthened with a range of reforms under preparation. Australia is developing a National Energy Performance Strategy to provide a national plan to accelerate demand-side action. The strategy was announced in October 2022 and will provide the framework to deliver the energy efficiency savings required to meet the government's 2030 and 2050 emissions reduction targets while reducing pressure on energy bills and improving energy security. The development of the strategy will consider energy efficiency targets and sectoral actions. The 2022-2023 Budget included AUD 62.6 million for an energy efficiency grants programme for small and

medium-sized enterprises (SMEs) to reduce energy use and lower energy bills. It also included funding to expand and modernise the national framework for product energy efficiency standards and the Nationwide House Energy Rating Scheme.

Australia's climate mitigation policies rely on its Carbon Crediting Scheme (formerly the ERF), the Safeguard Mechanism, the RET scheme, and funding through ARENA and the CEFC. The combination of the federal RET and other state/territory-based feed-in tariffs, along with saving obligations supported the uptake of wind and solar energy. Due to very low baselines for reductions, these have been more effective in accelerating emissions reductions than the ERF and Safeguard Mechanism. Australia has reformed the Safeguard Mechanism to strengthen baselines.

The power sector remains critical for achieving Australia's net zero target. While half of energy-related CO_2 emissions stem from the power sector and direct combustion in industry, those sectors are not subject to any effective carbon rate through energy or carbon taxes or emissions trading systems. Commendably, the government is including an emissions reduction objective in the National Energy Market under the National Energy Transformation Partnership, agreed with all states and territories in August 2022. The partnership could be instrumental and will be the foundation for a co-ordinated approach to climate and energy policies across Australia.

Regulated by the CER, Australia's Carbon Crediting Scheme (formerly the ERF) is a voluntary scheme which allows businesses and individuals to create ACCUs for eligible emissions avoidance and sequestration activities. Even though credits are generated through an expanding number of methodologies, most of the credits so far have been generated through projects in the land and agricultural sector. Facilities can surrender credits to offset emissions over their baseline in the context of the Safeguard Mechanism. The government has commissioned an independent review of the integrity of the offsets.

Stakeholders have criticised the fact that the baselines of the Safeguard Mechanism were set in a way that companies did not face actual emissions constraints. The government has indicated its intention to decrease the baselines and is consulting on the options for the reform. The decrease in safeguard baselines will reduce emissions from the industrial sector. Introducing a tradeable unit to recognise facilities emitting below baselines will help further incentivise reductions in the industrial sector.

Australia is beginning to develop policies and measures to promote low or zero emissions vehicles, low-emission fuels, transport sector efficiency, and modal shifts. It has set a low emissions vehicle target for the federal government fleet of 75% of new purchases and leases by 2025 and is developing a National Electric Vehicle Strategy, which has completed consultation. The National Electric Vehicle Strategy can be a catalyst for a more comprehensive policy package, including mobility programmes and efficiency measures under a refreshed approach with states and territories (see Chapter 4). The EV roll-out strategy is being co-ordinated with the strategy to move the power sector towards net zero emissions. This is important, as otherwise emissions from the transport sector may turn out to be higher than they are today.

Adapting to climate change impacts

Australia will need to urgently adapt to the impacts of climate change, which have increased (flooding, wildfires, heat waves), to enhance the resilience of the Australian society, with a particular focus on its energy system.

Australia's National Climate Resilience and Adaptation Strategy 2021-2025 takes a system-wide approach to adaptation and resilience-building across all domains, including the built environment, which encompasses energy system climate resilience.

Australia has not yet completed a comprehensive assessment of climate change impacts on the energy sector. To date, work has only been carried out in the electricity sector to understand the climate risks, with the Electricity Sector Climate Information Project. The Australian Energy Market Operator uses these data to inform electricity system planning, including the Integrated System Plan, as well as by market participants in the General Power System Risk Review process under the National Energy Rules. Developing a national-level energy sector plan that lays out future steps for climate resilience could further guide and accelerate co-ordinated action.

The Australian Government is working towards a national climate risk assessment that will feed into defining the priorities and plans for adaptation and resilience alongside improved climate information services.

Boosting climate financing

Australia's climate financing is sizeable and has grown, but is only around 26% of its total allocable bilateral ODA. The government prioritises its finance to support clean energy transitions and climate resilience in Asia and the Indo-Pacific at the regional level, including through blended finance activities and climate partnerships. The government should consider allocating revenues to a fund for global energy transitions, including by increasing allocations to the Green Climate Fund and other climate finance contributions.

Recommendations

The government of Australia should:

- ☐ Review Australia's long-term strategy taking a consultative approach to emissions reduction pathways, inclusive of the energy, agricultural, land-use, industry and waste sectors. For 2030, elaborate, with the participation of states/territories and various stakeholders, a comprehensive, whole-of-government national climate and energy strategy which lays out the actions to reach the targets for 2030 towards net zero emissions by 2050.
- ☐ As part of future annual climate change statements to parliament, update over time the impacts of current policies and measures on emissions projections, including energy efficiency, renewable energy and other clean energy technologies, and identify the need to strengthen policies and measures by sector.
- ☐ To ensure credible efficiency gains and emissions reductions in Australia's energy-intensive industries, strengthen the baselines, expand the scope of the Safeguard Mechanism and improve the integrity of the Australian Carbon Credit Units offsets based on the review.

- Review the progress of national adaptation actions and disaster resilience frameworks to inform the future adaptation strategy after 2025, with a view to energy sector impacts. Develop a national-level energy sector resilience plan that lays out future steps for climate resilience to anticipate and mitigate impacts and strengthen energy infrastructure resilience.
- Take steps to decarbonise the transport sector, reduce fuel demand and, ultimately, enhance liquid fuel security and reduce import dependency on oil products, based on a comprehensive strategy for low-emission fuels, vehicles and policies for modal shifts.

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4. Energy efficiency

Key data

(2021)

TFC*: 3 307 PJ, +0.1% from 2011 to 2021

TFC by source: oil 52%, electricity 24%, natural gas 16%, bioenergy and waste 5%, coal 3%

TFC by sector: industry 39%, transport 38%, buildings 23%

TFC per capita: 128.5 GJ/capita (IEA average in 2020: 112.8 GJ/capita), -21% since 2011

TFC per GDP**: 2.63 MJ/USD (IEA average in 2020: 2.66 MJ/USD), -13% since 2011

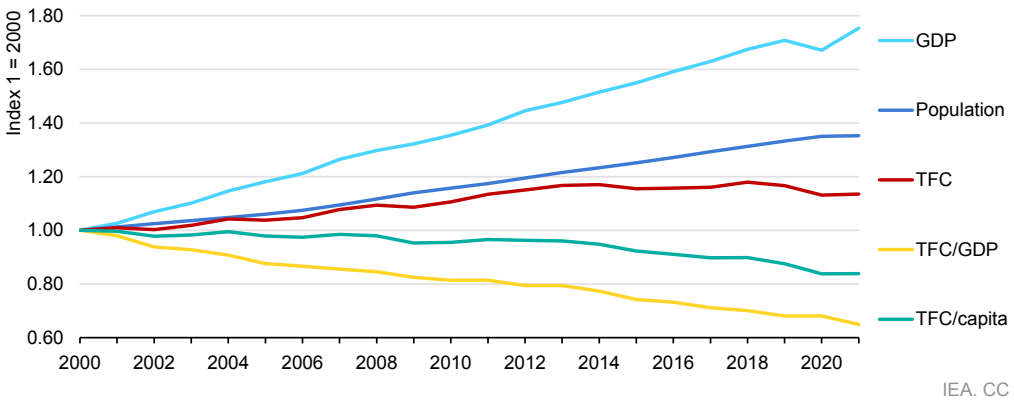
* TFC includes non-energy use in industry.

** GDP in 2015 prices and purchase power parity

Overview

Australia's total final consumption has broadly followed the GDP trend since 2005, albeit at a slower pace (Figure 4.1). Between 2000 and 2021, GDP increased by 75%, while TFC increased by only 13%, showing a decoupling between economic growth and energy demand. Since 2014, energy demand has remained relatively stable around an average of 3 370 PJ, even as GDP grew by 16% and population by 10%. In 2020, both GDP and TFC dropped markedly because of the Covid-19 pandemic. In 2021 GDP recovered to above 2019 levels, while TFC remained similar to the value in 2020.

Figure 4.1 Energy demand and drivers in Australia, 2000-2021



While Australian GDP increased by 75% between 2000 and 2021, TFC increased by 13%, showing some decoupling between economic growth and energy demand.

Notes: GDP = gross domestic product; TFC = total final consumption.

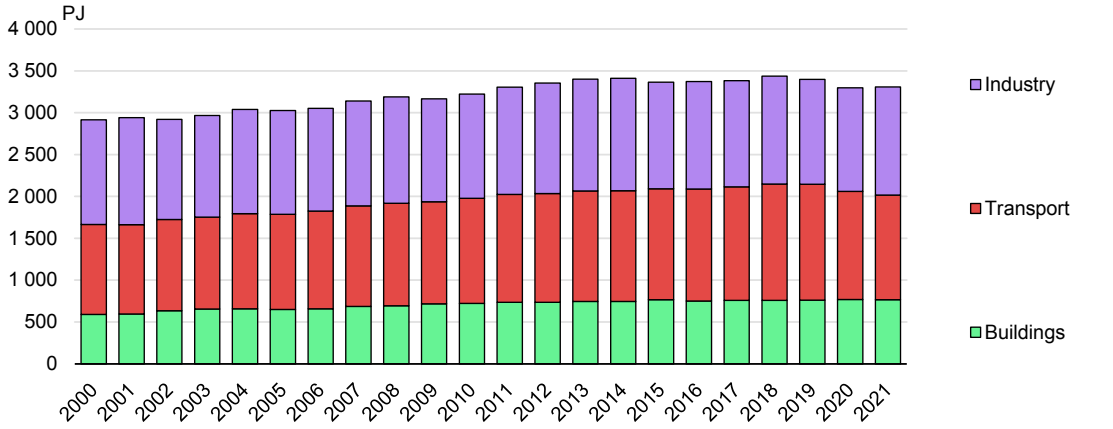
Source: IEA, (2022a).

Energy demand by sector and energy savings

From 2000 to 2021, Australia's energy demand (TFC) increased from 2 913 PJ to 3 307 PJ, mainly due to an increase in energy demand in the transport sector, which increased by 16% (Figure 4.2).

Industry and transport had a similar share of energy demand from 2010 to 2015, when transport bypassed industry to become the sector with the highest energy consumption. The share of transport decreased again in 2020 and 2021 because of the Covid-19 pandemic. In 2021 industry had the highest share in TFC (39%), followed by transport (38%) and buildings (23%).

Figure 4.2 Energy demand (TFC) by major end-use sector in Australia, 2000-2021



Energy consumption in transport and buildings has been increasing since 2000, while industry energy demand has been stable.

Notes: PJ = petajoule. Industry includes non-energy use. Non-energy use refers to fuels used as raw materials, not those used as fuel or transformed into another fuel. This comprises typically raw materials used in the chemical and petrochemical sector.

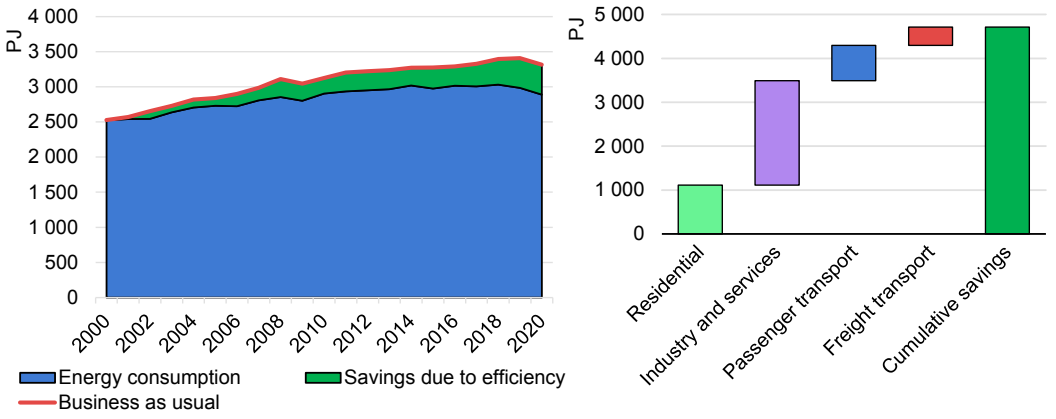
Source: IEA, (2022a).

According to IEA analysis, thanks to energy efficiency gains between 2000 and 2014, energy consumption in Australia increased at a slower pace than if the energy efficiency-related improvements had not been made. By 2014, efficiency gains were so significant that energy demand seemed to have stabilised at around 3 000 PJ before declining to reach 2 890 PJ in 2020, even as the economy and population grew (Figure 4.3).

Between 2000 and 2020, an average of 235 PJ was avoided each year thanks to the cumulative effect of energy savings and efficiency improvements. Over the 20-year period, a total of 4 714 PJ had been saved, 50% of which was from industry and services, followed by residential (24%), passenger transport (17%), and freight transport (9%).

In the residential and industry/services sectors, the installation of light emitting diode (LED) lights and more efficient appliances driven by stronger minimum energy performance standards have had a powerful impact.

Figure 4.3 Energy savings due to efficiency in Australia, 2000-2020



Energy efficiency improvements have allowed Australia to achieve energy savings since 2000, with the largest share of cumulative savings achieved in the industry and services sectors.

Note: PJ = petajoule.

Source: IEA, (2022a).

Energy efficiency strategy and targets

In October 2022, the Australian Government announced it will develop a National Energy Performance Strategy, which will provide a national plan to accelerate demand-side action, including energy efficiency (DCCEEW, 2022a). “Energy performance” encapsulates the broad management of energy demand. It includes energy efficiency, load shifting, fuel switching and behaviour change. The National Energy Performance Strategy will provide guidance on the long-term direction for energy performance. In developing the strategy, the Australian Government will consider energy efficiency targets and explore the role of the residential, commercial and industrial sectors in improving energy performance while contributing to emissions reduction targets.

Australia has approached energy efficiency in terms of energy productivity. As an indicator, this is defined as real GDP divided by primary energy consumption (the inverse of energy intensity). The NEPP aimed to improve energy productivity by 40% from 2015 to 2030. In March 2021, Australia’s National Greenhouse Gas Inventory forecast a further increase of energy productivity by 53% between 2015 and 2030, as GDP is expected to grow by 42% while energy consumption is expected to decline by 7% (DCCEEW, 2021).

Efficiency drives an early peak in emissions reductions

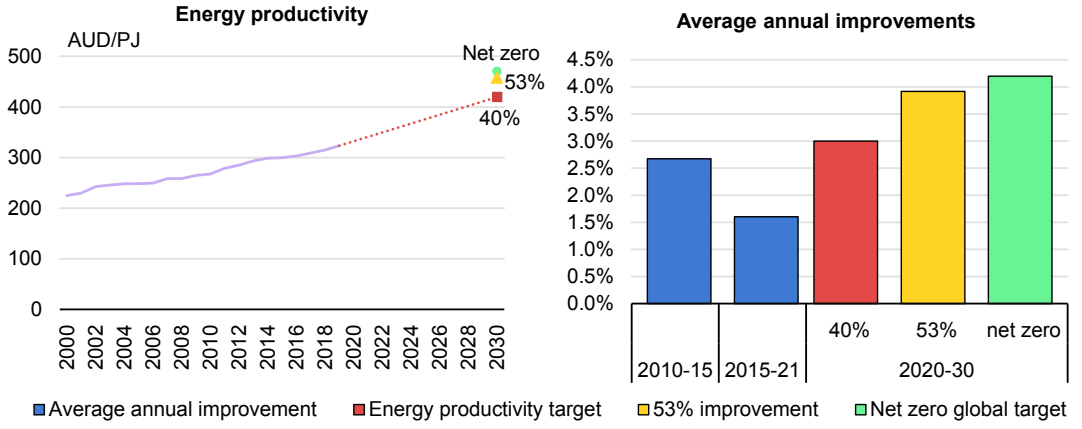
Australia’s energy efficiency, measured as energy productivity (GDP/TES), improved at a considerable pace from 2010 to 2015, at an average annual improvement rate of 2.7%. However, the rate slowed down markedly between 2015 and 2019, dropping to 1.9%, even if still higher than the global average of 1.6% in the same time frame. In 2020, energy efficiency improvements marked a significant slowdown (-3.6%) due to the Covid-19 pandemic but rebounded significantly in 2021 (5.3%).

To meet its targeted 40% productivity increase by 2030, Australia would need to reach an efficiency improvement rate of around 2.3% per year from 2015 to 2030. Under a net zero pathway, such as set out in the IEA global net zero roadmap, which stipulates a 4.2% efficiency improvement from 2020 to 2030 on average, Australia could achieve a 57% increase in productivity from 2020 to 2030.

Australia's 40% target would not yet be in line with a net zero ambition, while the 53% improvement mentioned in the March 2021 update of the National Greenhouse Gas Inventory approaches what would be required globally to achieve net zero.

Action needs to be accelerated, as do annual improvement rates from their recent slowdown from 2015 to 2019, to bring Australia back on track to reach its target and get closer to net zero. Hitting the target would mean Australia would decrease its energy consumption while continuing to increase its GDP.

Figure 4.4 Australia's average annual energy efficiency improvements and targets



Australia needs to at least double its average annual energy efficiency improvements to reach its energy productivity target to reach its targets for 2030, in line with net zero emissions goal.

Note: AUD/PJ = Australian dollar per petajoule.

Sources: IEA, (2022b; 2021).

Reducing household bills to mitigate the impacts of the global energy crisis

With upwards pressure on energy bills due to the global energy crisis being experienced worldwide, accelerating energy efficiency to reduce household and business energy expenditure is more relevant and urgent than ever before.

According to the Treasury, the budget forecasted a 56% hike in electricity prices over financial year 2022-2023, with gas prices rising by 44%. The ACCC confirmed that electricity bills have jumped by AUD 300 on average since April 2022. This is a 25% increase for the median residential household connected to the national electricity market and AUD 1 500 for small businesses.

This is also a key issue highlighted in the IEA's *Energy Efficiency Market Report 2022*, which shows how living in a more efficient home and driving a more efficient car can save consumers up to 70% on their household energy bill, depending on the existing efficiency of their homes and vehicles (IEA, 2022b).

An earlier ACCC report in 2018 stated that 30% of the lowest income households spend 8% on fuel, but this has greatly increased. Judging by the United Kingdom fuel poverty definition (10% of lowest income households), energy poverty is an issue in Australia.

The critical importance of lowering energy bills has also been emphasised by the new government's election commitment to implement new renewable energy support policies, projected at the time to lower consumer energy bills by AUD 275 per household by 2025.

Energy efficiency policy strategy and governance

Responsibilities for energy efficiency policy are shared between the Australian Government and state and territory governments. Joint policy initiatives are pursued through the Energy and Climate Ministerial Council (ECMC), as is a forum for the Commonwealth, Australian states and territories, and New Zealand to work together. While energy efficiency was not very present in the past decade in the EMM, it has been recognised as a key focus of the newly formed National Energy Transformation Partnership.

The Australian Government is responsible for setting a national policy agenda (through model codes and standards) and delivering national programmes. The states and territories deliver a range of state-based energy efficiency programmes. At the Commonwealth level, the Australian Government has important policy levers, including regulatory harmonisation, best practices, minimum standards for product efficiency and buildings performance, rating and labelling, and market monitoring with regard to consumer choice and funding. A few highlights include the Commercial Building Disclosure, the National Construction Code, Greenhouse and Energy Minimum Standards, the National Energy Analytics Research, the national energy customer framework, or the Cities Taskforce to support the development of the Commonwealth's agenda for cities.

The DCCEEW is the main federal government agency on energy efficiency policy making. Primary administration and oversight of the NEPP and related measures are undertaken through a joint intergovernmental forum that reports to the EMM. Development of the National Energy Performance Strategy will consider broader work being conducted by Commonwealth and state and territory governments. Energy efficiency programmes are funded by the states/territories and under ARENA[5] and the CEFC. The development of transport fuel economy standards will be the responsibility of the Department of Infrastructure, Transport, Regional Development, Communications and the Arts.

Cross-sector policies

Australia's Carbon Crediting Scheme (formerly the ERF) is a policy to encourage cross-sector savings (see Chapter 3). In its 2020 review of the scheme, the CCA gave recommendations with regard to efficiency. For example, it recommended the greater ambition on implementing the NEPP and resources to accelerate measures that reduce

[5] On 22 July 2022, ARENA expanded its mandate to include and support energy efficiency and electrification technologies.

emissions, lower business costs, reduce energy bills and improve health outcomes for households. The CCA also recommended the introduction of a national energy savings scheme, which could harmonise and extend the schemes currently operating in some states and territories. However, to date, the scheme does not incentivise energy efficiency investment, despite ample opportunities for investment with short-term payback times, notably in industry.

The Equipment Energy Efficiency (E3) programme, administered by the Australian Government in conjunction with the states and territories, works to increase the energy efficiency of new appliances and equipment through mandatory energy efficiency regulations, under the GEMS Act. The latest E3 Prioritisation Plan 2021-2022 sets the E3 work programme for the next five years.

In the area of building efficiency, the National Construction Code is reviewed regularly. It was updated in 2022 to increase the minimum energy efficiency requirements for new residential buildings – increasing the "star" rating for the thermal shell and setting an energy budget that takes into account solar energy generated onsite; battery storage; and the energy performance of appliances used for hot water, lighting, heating and cooling.

Energy efficiency data are not readily available. The NGERS scheme is a national framework for reporting and disseminating company information about GHG emissions and energy production and consumption. It is administered by the CER. Corporations that meet the emissions threshold (detailed in Chapter 2) must register under the framework and report each year.

In October 2022, the government presented the 2022-2023 Budget, which provides for several energy efficiency-related funding programmes, including:

- AUD 62.6 million in funding to support SMEs making energy efficiency upgrades
- AUD 15.2 million to develop the National Energy Performance Strategy
- AUD 4.6 million to expand and modernise the Greenhouse and Energy Minimum Standards scheme and improve the Nationwide House Energy Rating Scheme.

Buildings

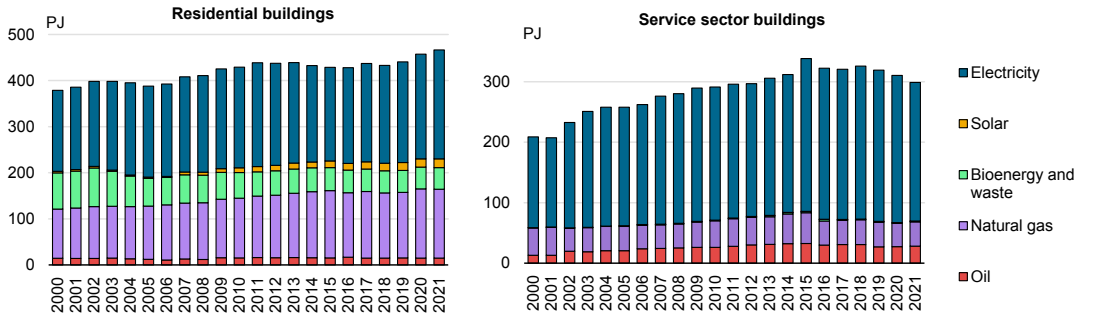
In 2021, there were 10.85 million residential dwellings in Australia. Of these, 70% were individual houses, 13% were townhouses and 16% apartments (ABS, 2022).

Residential buildings' energy demand is higher than that of service sector buildings, and accounts for 61% of buildings' TFC in 2021 (Figure 4.5).

From 2000 to 2021, electricity was the main source of energy in buildings (61% in 2021), playing an important role in residential buildings (51%) but more so in service sector buildings (77%).

The second-largest energy source for buildings is natural gas (25% in 2021), accounting for a large share especially in residential buildings (32%). Bioenergy and waste supplied 6.2% and oil 5.7% of energy to buildings in 2021.

Figure 4.5 Total final consumption in the building sector by source in Australia, 2000-2021



TFC has increased in residential and service sector buildings, dominated by electricity and an increasing use of natural gas. Service sector buildings have seen a decline since 2018.

Note: PJ = petajoule.

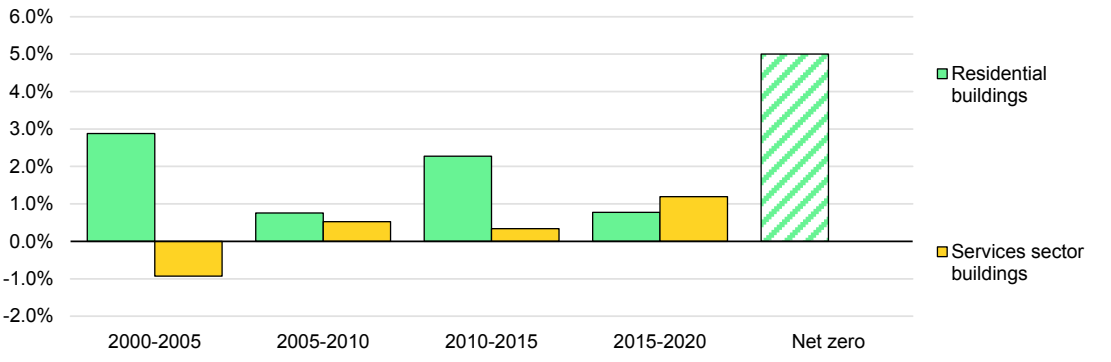
Source: IEA, (2022a).

The net zero pathway under the IEA Net Zero Roadmap requires a 5% improvement per year globally for residential buildings (IEA, 2021, 2022c).

Space heating is the end-use sector with the highest energy consumption, representing 36% of the residential sector energy demand in 2018 (Figure 4.7). Water heating accounted for 27% of residential energy demand, appliances 23%, cooking 5%, lighting (4%) and space cooling 5%.

Energy consumption for cooling has doubled since 2000. Energy consumption for lighting peaked in 2004 then decreased sharply by 55% from 2004 to 2020, thanks to the deployment of more efficient LED technology.

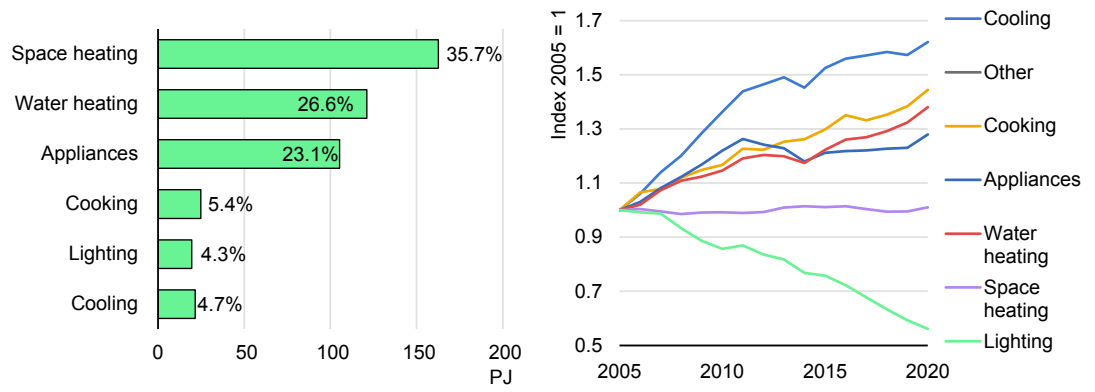
Figure 4.6 Average annual energy efficiency improvements in the buildings sector in Australia, 2000-2020



Average annual energy efficiency improvements in the residential sector are decreasing and energy efficiency improvements in the service sector are increasing.

Source: IEA, (2022c, 2021).

Figure 4.7 Energy consumption in the residential sector in Australia by end-use, 2020 and change since 2005



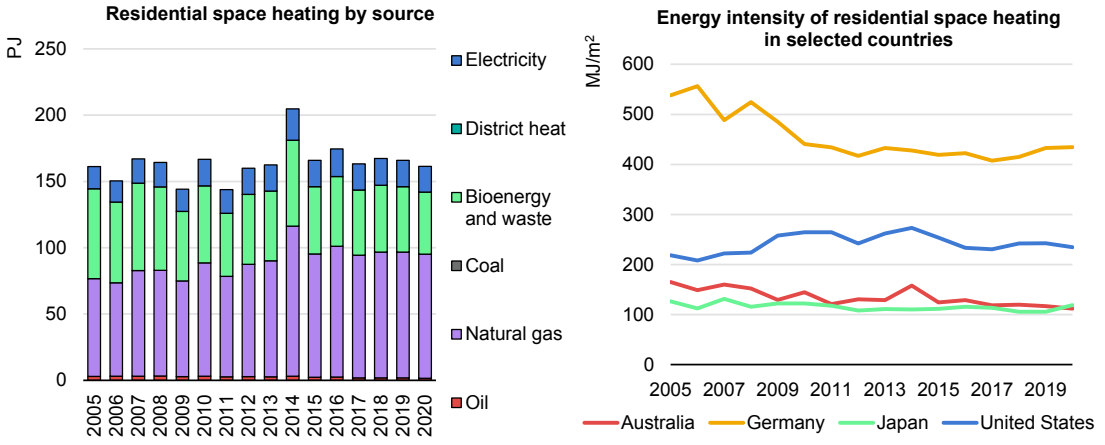
Space heating accounts for more than one-third of residential energy consumption. Since 2005, cooling demand has increased, while that for lighting has significantly decreased.

Source: IEA, (2022a).

Space heating – the highest energy-consuming end-use in the residential sector – is fuelled mainly by natural gas (58%), followed by bioenergy (29%) and electricity (12%) (Figure 4.8).

The energy intensity of residential space heating decreased by 14% from 2010 to 2020 and is lower than in Germany and the United States but higher than in Japan. The energy intensity of space heating (112 megajoules per square metre [MJ/m^2]) in Australia is already lower than the global benchmark in the net zero scenario (285 MJ/m^2).

Figure 4.8 Space heating energy consumption by source in Australia and energy intensity of space heating in selected countries



Natural gas and bioenergy dominate energy consumption for space heating. The energy intensity of space heating in Australia is decreasing and lower than in other IEA countries.

Notes: PJ = petajoule; MJ/m² = megajoule per square metre. The energy intensity data are temperature-corrected.
Source: IEA, (2022a).

Energy efficiency policies in the buildings sector

Commercial buildings have seen a considerable improvement in energy efficiency thanks to successful disclosure and labelling mandates. However, progress in residential buildings is still lagging behind and does not have energy performance certificates like in Europe.

Low-income households still live in poorly insulated houses and inefficient buildings without efficient housing envelopes. On the other hand, many private homeowners have installed solar PV and battery systems and have low-energy buildings.

Trajectory for Low Energy Buildings

The Trajectory for Low Energy Buildings is Australia's net zero energy- (and carbon-) ready commercial and residential building sectors strategy. It has an Addendum to the Trajectory for Low Energy Buildings – Existing Buildings, which identifies measures to enable existing buildings to be net zero energy-ready. To implement the trajectory, the government aims at:

- implementing cost-effective increases to the energy efficiency provisions in the National Construction Code (NCC) for residential and commercial buildings from 2022
- developing information, training and energy-rating tools for households and businesses to enable a greater understanding of energy efficiency options and applications
- developing and expanding targeted building policies, including disclosure of energy performance; minimum energy efficiency standards for rental properties; renovations and refurbishments; improving heating, ventilation and cooling systems; and energy productivity in government operations
- identifying and developing supporting measures, including specific measures for strata-titled buildings, financial initiatives, appliance standards and labelling, specific measures for vulnerable households, a national data set and collection process for existing homes, and other targeted initiatives.

Building codes, labelling and certification systems

The Australian Building Code has been strengthened since the IEA's last review in 2018. Following consultation on the NCC in 2022 by the Australian Building Codes Board, in August 2022, the government agreed to increase the minimum energy performance standards for residential buildings, which will be mandatory from 1 October 2023. Work has begun on the next triennial update to the energy efficiency provisions under the NCC, which is due in 2025 and will focus on commercial buildings.

The Commercial Building Disclosure Program requires energy efficiency information to be provided in most cases when commercial office space of 1 000 m² or more is offered for sale or lease. The programme has been very effective; however, it does not yet cover some sectors where voluntary NABERS energy ratings are available such as hotels, shopping centres or data centres.

Commercial building energy use certification is available through the voluntary National Australian Built Environment Rating System (NABERS). NABERS is a national programme providing energy ratings to commercial buildings. Over 4 500 commercial buildings have been rated at least once during over the life of the programme. The Australian Government is funding the expansion of NABERS energy ratings with residential aged care and

retirement living buildings added in 2021 and warehouses and cold stores added in 2022. These join NABERS ratings for offices, shopping centres, data centres, hotels, apartment buildings, public hospitals and office tenancies.

The Nationwide House Energy Rating Scheme (NatHERS) measures a residential building's energy performance. For new homes and major renovations, the scheme can now rate the energy performance for the whole house, including the major appliances, solar panels and batteries, in addition to the star rating for the building shell. It can be used to meet and beat requirements in the Australian NCC. NatHERS is also expanding to include voluntary energy assessments for established homes.

Your Home is Australia's guide to designing and building energy-efficient, sustainable homes. It provides nationally consistent information to help the building sector deliver energy efficiency improvements in line with national building regulations.

The Victorian and New South Wales governments stand out for having strong programmes to save energy from government operations (e.g. hospitals, government offices, water corporations); not many other governments in Australia have shown public leadership with green procurement and renovation.

Industry

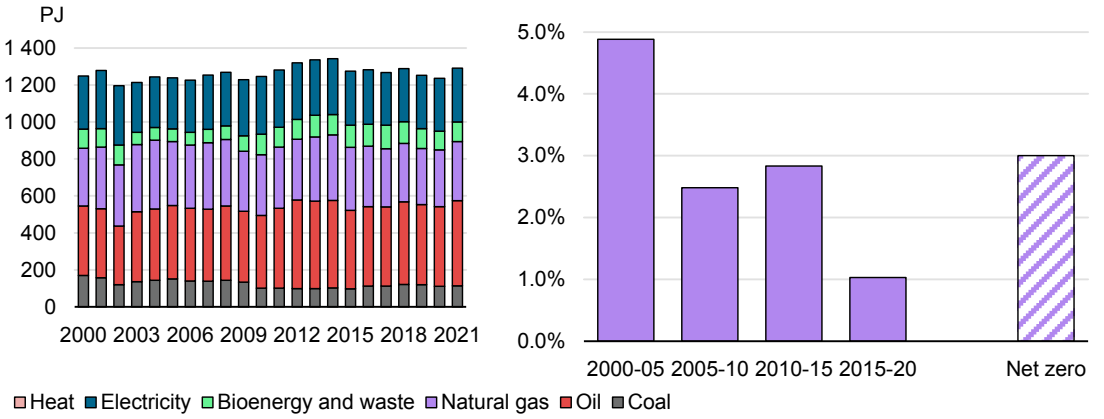
Before 2014, the industry sector (including non-energy use)[6] held the largest share of TFC. Since 2015, transport has become the leading end-use sector until 2021, when industry was again first. Industrial energy consumption fluctuated around an average of 1 270 PJ between 2015 and 2021.

In 2021, the main energy source in the industry sector was oil (36%), followed by natural gas (25%), electricity (22%), coal (9%), and bioenergy and waste (8%) (Figure 4.9).

Progress in industrial energy efficiency has slowed over the past years, with the lowest average annual efficiency improvements recorded between 2015 and 2020. In line with the global net zero emissions target of 3%, industry will need to accelerate its performance, policies and programmes (IEA, 2022b).

6 Non-energy use refers to fuels used as raw materials, not those used as fuel or transformed into another fuel. This comprises typically raw materials used in the chemical and petrochemical sector.

Figure 4.9 Total final consumption in industry by source, 2000-2021, and average annual energy efficiency improvements in industry in Australia, 2000-2020

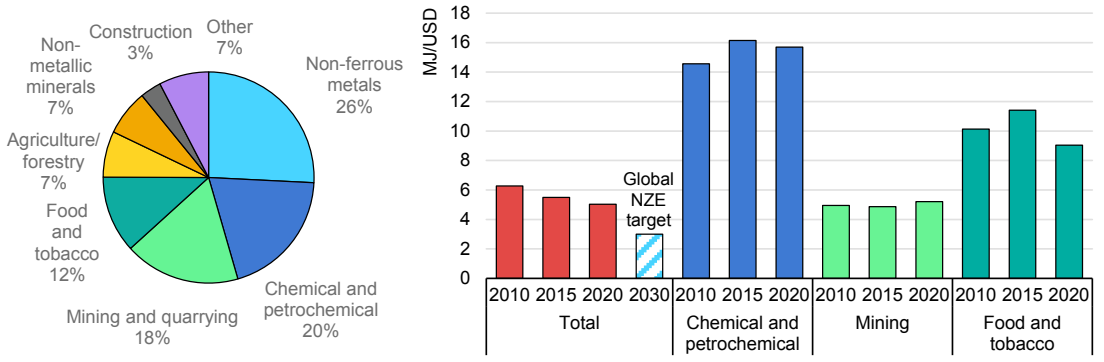


Oil and natural gas dominate industry's energy consumption. Average annual energy efficiency improvements are down from past levels, far from net zero emissions improvements (3%).

Note: PJ = petajoule.
Source: IEA, (2022a, 2022c).

The main industrial subsectors in TFC in Australia are non-ferrous metals, chemical and petrochemical, and mining and quarrying, which together account for two-thirds of industry TFC (Figure 4.10). In terms of energy intensity per value added, the manufacturing sector has achieved significant efficiency gains, decreasing its energy intensity by 11% between 2010 and 2020. However, the energy intensity of the mining sector increased by 9% in the same period. The largest energy-consuming industrial sector in 2020 was non-ferrous metals, accounting for 26% of industrial consumption. The other main sectors in terms of energy demand were chemicals and petrochemicals (20%), mining and quarrying (18%), food and tobacco (12%), agriculture and forestry (7%), non-metallic minerals (7%), and construction (3%). The energy intensity of the industry sector in terms of energy intensity per value added increased by 4% from 2005 to 2019.

Figure 4.10 Total final consumption in industry by subsector in 2020 and energy intensity per value added in Australia



Metals, chemical and petrochemical, mining and quarrying cover two-thirds of industrial energy consumption. The energy intensity per value added of the industry sector has decreased.

Notes: MJ/USD = megajoule per USD. NZE = net zero emissions scenario target.
Source: IEA, (2022a, 2022c).

Energy efficiency policies in the industry sector

Minimum energy performance standards apply to electric motors, chillers, refrigerated display cabinets and distribution transformers. Three additional products (pumps, air compressors and boilers) were identified as top priorities in the E3 Program 2021-2022 prioritisation plan.

The Australian Government is delivering an AUD 62.6 million Energy Efficiency Grants for Small and Medium Enterprises programme for the period 2022-2023. It will support SMEs in upgrading or replacing inefficient technologies to improve energy efficiency. On 22 July 2022, the Australian Government expanded ARENA's mandate to include and support energy efficiency and electrification technologies.

In 2017, the Energy Efficiency Council and New South Wales Office of Environment and Heritage developed a Quick Reference Guide to Energy Auditing, focused on commercial and industrial audits.

Transport

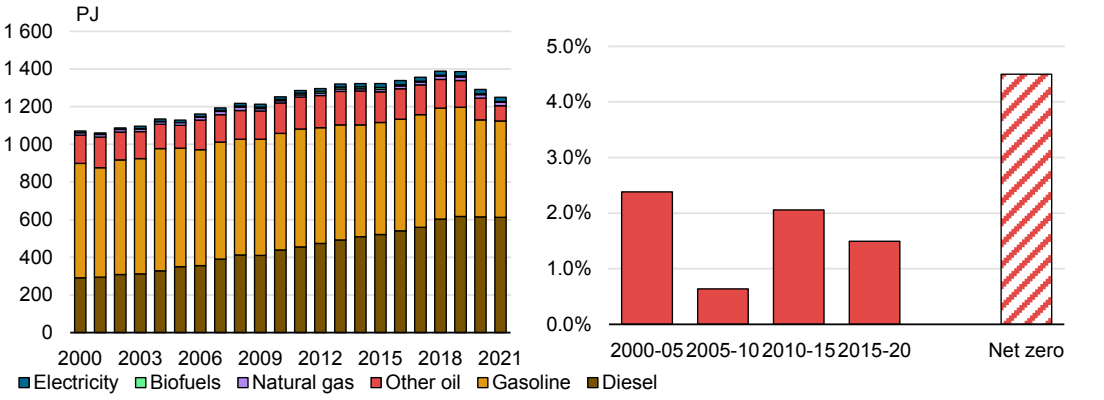
Transport sector energy demand increased from 920 PJ in 2000 to 1 265 PJ in 2019 (Figure 4.11). In 2020, the Covid-19 pandemic and the related restrictions caused a 6% drop in energy demand in transport with respect to 2019, and the decrease continued in 2021 when demand by transport was 1250 PJ, 10% lower than 2019. The main fuel used in the transport sector is diesel, which covered 49% of transport energy demand in 2021, followed by gasoline (41%) and other oil products (7%). Smaller shares come from natural electricity (2%), gas (1%), and biofuels (0.3%).

In 2021, Australia had almost 20 million vehicles, of which 15 million passenger cars and 3.5 million light commercial vehicles.

Most energy demand in the transport sector comes from road transport, which accounted for 81% of transport energy use in 2019. Aviation accounted for 9% of transport energy the same year, while rail transport and navigation accounted for 4% and 2%, respectively.

All the transport sectors rely on oil products. Electricity accounts for 2% of total transport demand and is used mainly in rail, even if it accounts for only 20% of total rail energy demand, which is covered by diesel for 79.8%. With the increasing supply of EVs, the share of electricity in road transport has grown almost tenfold since 2013, but it is still very small at 0.008%.

Figure 4.11 Total final consumption in transport by fuel, 2000-2021 and average annual energy efficiency improvements in the transport sector in Australia, 2000-2020



TFC in transport has increased since 2000, mostly driven by diesel demand. Average annual energy efficiency improvements have been in decline and remain far from net zero.

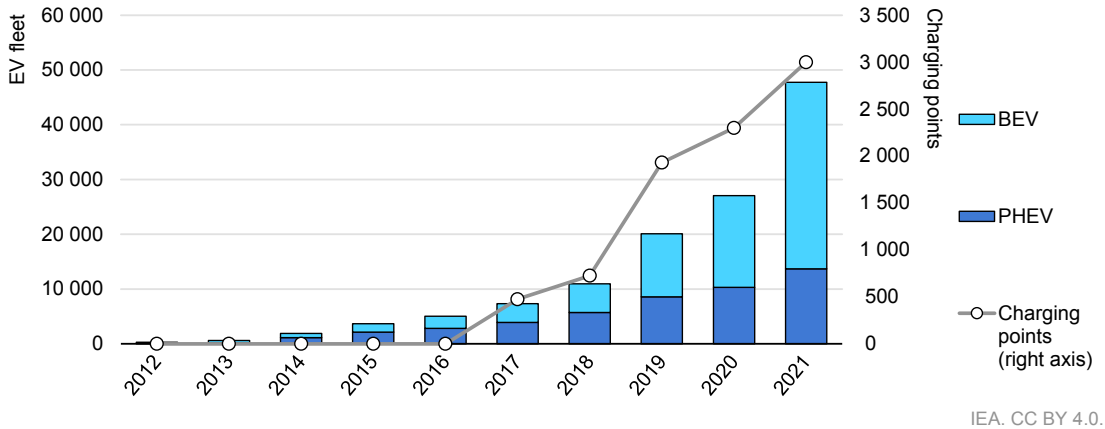
Note: PJ = petajoule.

Source: IEA, (2022a, 2022c).

The global net zero annual improvement from 2020 to 2030 is around 4.5% per year for passenger cars (IEA, 2022b). Road transport accounted for 90% of transport energy consumption in Australia in 2021.

EV deployment is rising in Australia, with a steep increase in 2021, when EV sales tripled from the previous year (Figure 4.12). Between 2018 and 2021, the number of EV sales increased from 2 216 to 20 665. While Australia's EV market is expanding, it is still lagging behind other large western countries. The share of EV sales among total car sales in 2021 was 2%, below the IEA average of 9%. According to the Electric Vehicle Council, EVs represented 3.4% of all vehicle sales in 2022. Publicly available charging points have also ramped up since 2018, reaching more than 3 000 in 2021. In 2021, the EV fleet comprised 34 043 battery electric vehicles (BEVs) and 13 701 plug-in hybrid electric vehicles (PHEVs), representing 0.4% of the country's total car fleet.

Figure 4.12 Electric vehicle fleet and public charging points in Australia, 2012-2021



Australia's EV fleet has increased exponentially since 2012 to reach almost 50 000 EVs in 2021, with two-thirds from BEV and 3 000 charging stations deployed across the country.

Notes: BEV = battery electric vehicles; PHEV = plug-in hybrid electric vehicles. Charging points include fast and slow chargers.

Source: IEA, (2021). Global EV Data Explorer.

Under the Powering Australia plan, Australia has set a low emissions vehicle target for the federal government fleet of 75% of new purchases and leases by 2025 and is developing a National Electric Vehicle Strategy, which has completed consultation. The Australian Government will work with states, territories and industry to look at demand and supply-side measures to dramatically scale up EV uptake by 2030. The strategy will build on state-level targets and programmes and consider options for introducing fuel efficiency standards for light vehicles.

Four out of the eight Australian states have pledged to reach the COP26 declaration target on zero emission vehicles: "all sales of new cars and vans are zero emission globally by 2040, and by no later than 2035 in leading markets".

Six out of eight states have set targets to increase the share of EVs in their fleet (Table 4.1).

Table 4.1 Australia's electric vehicle targets by state

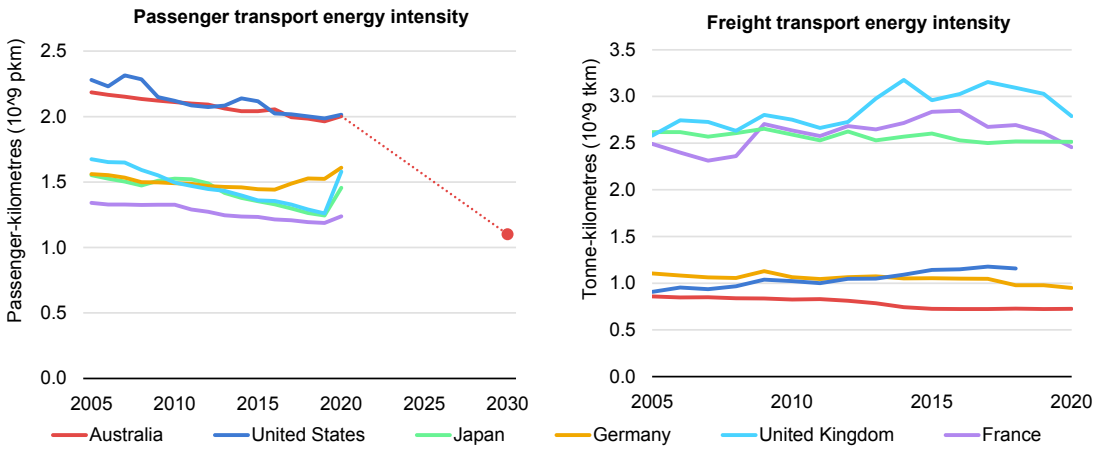
State	Strategy	% of electric vehicles in vehicle sales (2022)	Electric vehicle targets	Incentives	COP26 declaration pledge
New South Wales	NSW Electric Vehicle Strategy (2021)	3.7%	52% of sales will be electric vehicles (EVs) by 2030-31	AUD 3 000 rebates for first 25 000 EVs purchased for less than AUD 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 Emission 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

State	Strategy	% of electric vehicles in vehicle sales (2022)	Electric vehicle targets	Incentives	COP26 declaration pledge
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.

The energy intensity of both passenger and freight transport is decreasing in Australia (Figure 4.13). However, compared to other IEA countries, it is the highest for passenger transport. The energy intensity of freight transport is relatively low. Very strong efficiency efforts are needed to align with net zero ambitions in the transport sector, based on the IEA *Tracking Clean Energy Progress 2022* (IEA, 2022c), as illustrated in Figure 4.13.

Figure 4.13 Energy intensity of passenger and freight transport in Australia, 2005-2020 and global net zero target



Australia's passenger transport intensity is one of the highest in the IEA and far from the global net zero emissions target, while freight transport intensity is among the lowest.

Note: Global net zero emissions target is illustrated by the dashed red line.
Source: IEA, (2022a, 2022c).

Clean energy supply chains

The high number of EV sales since 2020 and the tight supply chains worldwide due to the aftermath of the Covid-19 pandemic and Russia's invasion of Ukraine have put the EV

supply chain under pressure. Most critical minerals essential for EVs are mined in resource-rich countries such as Australia, Chile, Indonesia and the Democratic Republic of Congo. The rest of the supply chain, which includes processing critical minerals and manufacturing batteries, is concentrated in a very few countries, with the largest share in China.

EV batteries are mainly composed of lithium, cobalt, nickel and graphite. Lithium mining is a very concentrated market, with more than half the world's lithium produced in Australia. Australia holds the largest nickel reserves, alongside Indonesia, with 22% of global reserves. However, Australia accounts for only 6% of current global production. Australia also has the second-largest cobalt reserves, with almost 20%, while accounting for only 3% of current production (see Chapter 11 for more details).

To ease the currently tight supply chain and meet its EV target, Australia should consider increasing its production and processing of critical minerals and establishing battery factories. Australia has the potential to become a major critical minerals and battery exporter. This would increase the number of EVs available to the market and therefore meet the increasing demand and ultimately decrease the price of EVs.

Mining is sensible to the mineral market prices. For instance, due to low lithium prices in 2019 and 2020, the Australian mining company Galaxy Resources, along with other Australian lithium mining companies, reduced lithium mine production at its most important mine by about 40%. Lithium prices reached an all-time high in 2022 (+200% since 2021). This will likely incentivise Australia to increase production.

In September 2021, the government released an AUD 1.3 billion loan facility for Australian critical minerals targeted for advanced sectors, including EV battery production. In addition, an AUD 2 billion fund was announced to increase critical mineral processing capacity, including for battery minerals and metals. In December 2021, the federal government awarded the "Major Project Status" title to an AUD 2.4 billion battery minerals complex in New South Wales for a nickel and cobalt mine, materials processing, and recycling facility.

Energy efficiency policies in the transport sector

Road vehicle policies

The government announced the development of Australia's first National Electric Vehicle Strategy and finished a consultation on the strategy in October 2022. To implement the Powering Australia plan, the National Electric Vehicle Strategy aims to roll out a national EV charging network (with charging stations at an average interval of 150 km on major roads), a national hydrogen highways refuelling network, and a low emissions vehicle target for the Commonwealth fleet of 75% of new leases and purchases by 2025. The national network would be financed by creating a AUD 500 million Driving the Nation Fund.

Australia does not use fuel taxation or fuel economy standards for stimulating the roll-out of EVs but has a number of national and state subsidy programmes, which are neither aligned nor co-ordinated. Australia does not have Corporate Average Fuel Economy (CAFE) standards (but labelling and fuel quality standards). CAFE standards are proposed as part of the National Electric Vehicle Strategy. Consultation on these reforms is underway.

The fuel consumption labelling standard under Australian Design Rule 81/02 requires a label to be placed on all new model cars, sport utility vehicles and light commercial vehicles, which provides data on fuel consumption and CO_2 emissions. In May 2021, the Australian Government announced the acceleration of the industry-wide review of the petrol and diesel standard to 2021, including consideration of aromatics levels, to create a Euro-6 equivalent petrol and diesel standard appropriate.

The government has co-founded the roll-out of charging and refuelling infrastructure under the AUD 250 million Future Fuels Fund since 2021. The fund enables businesses to integrate new vehicle technologies into their fleets. ARENA supports the roll-out of over 400 public fast-charging stations in the first round of funding. The Freight Energy Productivity Program, delivered by ARENA, is designed to support new truck technology and reduce barriers to energy productivity improvements in the heavy road freight sector.

Since 2016, the CEFC has made over AUD 1.3 billion available for low emissions vehicle uptake and related charging, manufacturing and recycling projects. This includes co-finance programmes with major banks and non-bank lenders for low and zero emissions vehicles. The CEFC launched AUD 100 million in financing programmes for these purposes.

The Electric Car Discount Bill was adopted by parliament and exempts eligible electric cars from fringe benefits tax and import tariffs. The Australian Government currently offers a luxury car tax concession for vehicles identified as fuel-efficient (combined fuel consumption less than 7.0 L/100 km), through a higher value threshold for these vehicles. Some state and territory governments also offer a concession on stamp duty or vehicle registration charges for low CO_2 and/or hybrid/EVs.

The Green Vehicle Guide provides information to consumers on the environmental performance of new cars and light commercial vehicles sold in Australia. The website enables consumers to compare the fuel consumption and emissions performance of individual vehicle models and to calculate annual fuel costs.

Rail, marine and aviation transport policies

Australia's Carbon Crediting Scheme (formerly the ERF) includes a Land and Sea Transport Method that provides incentives for a range of activities to improve the energy efficiency of road and rail vehicles. Eligible activities include upgrading vehicles, driver training and fuel switching. As of January 2020, only one transport project has accrued ACCUs, but 14 large emitters/transport enterprises are covered under the Safeguard Mechanism, mainly rail, air and maritime transport operators.

Assessment

To mitigate the impact of the triple global energy, climate and economic crises, energy efficiency offers a range of multiple benefits: it helps reduce energy costs, emissions and oil import dependency.

The Australian Government has increased its climate ambitions with a legislated NDC and a target for GHG reductions of 43% by 2030 from 2005 levels. The expected contribution of energy efficiency in achieving an early peak in emissions and the new climate goals remain to be defined.

The role of energy efficiency is now gaining traction for implementing Australia's new climate pledges and the National Energy Transformation Partnership. In 2022, the Australian Government aimed to accelerate progress on the energy demand side. It published a National Energy Performance Strategy for consultation as a framework for the Australian Government to provide guidance on the longer-term direction for energy performance. The NEPS also considers the introduction of sector targets, which is also a recommendation from this IEA review. The NEPS will help deliver a least-cost pathway through Australia's energy transition while meeting the government's emissions reduction targets and improving energy affordability.

Australia has witnessed the decoupling of economic growth and energy demand. Between 2000 and 2021, GDP increased by 75% while Australia's energy demand (TFC) increased by only 13% (from 2 913 PJ to 3 307 PJ), mainly due to an increase in energy demand in the transport sector. In 2015, transport became the highest energy-consuming sector, replacing the industry sector (including non-energy use).

To date, Australia does not yet have sectoral targets for energy efficiency, which is measured as overall energy productivity, based on the NEPP and its goal of reaching at least 40% between 2015 and 2030. In 2021, the government expected to overachieve the productivity goal, with a 53% increase in productivity for 2030. However, the productivity target, measured in primary energy use, does not necessarily value energy efficiency gains on the demand side. The projected increase in the share of renewable energy to the targeted 82% for Australia's power generation and the closure of coal plants will reduce generation losses.

Australian energy efficiency improvement slowed down between 2015 and 2020, with an annual rate of around 1.9%. Energy efficiency improvements need to double to reach a net zero pathway, in line with the global IEA 2030 net zero target of around 4.2% from 2020 to 2030 on average, which compares to a 57% productivity improvement for Australia. It would be timely to carry out an assessment of what a net zero pathway would mean for Australia's energy efficiency ambition. The National Energy Performance Strategy is a major opportunity to clarify the role of energy efficiency in the Australian energy transformation. Not only can energy efficiency contribute to net zero goals and lower energy bills for consumers, it also reduces required investment in new power generation and transmission capacity, increases the competitive position of industry, and relieves pressure on the electricity market.

Responsibilities for energy efficiency policy are shared between the government at the federal, state and territory levels. The NEEP was a joint initiative, which required a large amount of co-ordination. The Australian Government should indeed take the lead in setting a national policy agenda (through model codes, regulation and standards) and delivering national programmes, while the states and territories provide a range of state- and territory-based energy efficiency programmes.

Strengthening the energy efficiency funding programmes and the mandate of the Clean Energy Regulator could support the implementation of energy efficiency measures which lead to cost-effective emissions reductions. The Clean Energy Finance Corporation and ARENA have mandates that now include energy efficiency and should support the roll-out of a new energy efficiency/renewable energy funding programme, targeting renovation grants for low- to middle-income households.

Transport

In 2021, Australia had almost 19 million light duty vehicles, with 15 million passenger cars and 3.8 million commercial light duty vehicles (BITRE, 2022). EV deployment is rising in Australia. Between 2018 and 2021, the number of EV sales increased from 2 216 to 20 665. While Australia's EV market is expanding to 2% of the fleet, it is still lagging behind other advanced economies (the IEA average penetration rate is 9%). The government announced a broad policy package to increase the uptake of EVs with the National Electric Vehicle Strategy, with a proposal for new minimum standards for zero emissions vehicles. At the state and territory level, different EV policy initiatives are being deployed as well.

Outside labelling and fuel quality standards, Australia does not have CAFE standards nor levy carbon-content related vehicle or energy taxes. To date, it relies on the increase in the share of low emissions vehicles, mainly EVs, through plans for a national charging network and incentive programmes and targets.

Without CAFE standards, the Australian market will remain behind other OECD countries in terms of the supply and manufacturing of low emissions vehicles. Currently, Australian demand for EVs already exceeds supply, with waiting times of 12 months or more for hybrids and EVs. Any EV strategy must also consider critical mineral supply chain concerns and the rate of progress in power sector decarbonisation.

The National Electric Vehicle Strategy contemplates, among others, introducing fuel economy standards, which are under consultation.

Industry

Companies focus on their core business and traditionally pay limited attention to the potential benefits of energy efficiency measures. However, they may also consider changes to their production a risk. Specific energy efficiency policy (and the current high energy prices) could address this.

The Climate Active Certification programme implicitly incentivises companies, both large and small, to implement efficiency measures to achieve net zero emissions. The National Greenhouse and Energy Reporting Scheme is an effective policy that requires reporting based on identified minimum thresholds for scope one and two emissions (50 kilotonnes [kt] or more), energy production (more than 200 terajoules [TJ]) and energy consumption (more than 200 TJ). As these companies are required to report on their energy use, identifying and implementing energy efficiency measures would be a small step.

Efficiency is also part of the Australian Carbon Crediting Scheme and the Safeguard Mechanism, which requires reporting from facilities emitting over 100 000 t CO_2 emissions. However, in practice, low baselines, the methodologies and the voluntary character of these instruments do not lead to the implementation of energy efficiency measures. At the state level, requirements and incentives exist for audits, but since the cancellation of the national Energy Efficiency Opportunities programme in 2014, there is no country-wide scheme for auditing cost-effective energy efficiency measures and implementing identified measures.

It is commendable that the government's 2022-2023 Budget includes an energy efficiency programme for SMEs, implementing IEA analysis which finds that up to 60% of total energy savings can come from the less intensive companies. SME manufacturers face difficulties

in identifying and financing efficiency actions. Moreover, they lack the awareness and expertise to identify efficiency possibilities and access to subsidies or other instruments. In the Netherlands, for instance, SMEs can use a sector-specific predefined catalogue of measures they should implement, which avoids complex auditing procedures and clarifies the efficiency actions to take.

The GEMS Act is an effective way of regulating appliances. Currently, 24 appliance types have been regulated. This is fewer than the number of regulated appliances in the European Union or the United States. This creates a risk of dumping less efficient appliances on the Australian market. Through the E3 Prioritisation Plan, states/territories and federal governments decide together on new appliances that could be added to the regulation. Recent updates to the appliance regulations should enable industry to expand submetering and boiler replacements, which are among the low-hanging investment opportunities with under two-year payback periods.

Buildings

Residential buildings' energy demand is greater than that of service sector buildings, and accounts for 61% of buildings' TFC in 2021. Services sector buildings have seen a slight decline in consumption in the past few years.

Energy efficiency policy in buildings mainly focuses on newly constructed buildings, whereas a massive challenge and energy efficiency potential remain in retrofitting the existing building stock on the road to net zero emissions by 2050.

In 2019, the Australian Government adopted a Trajectory for Low Energy Buildings for new commercial and residential buildings. However, despite providing a timeline and policy options, it does not define specific goals (e.g. number of retrofitted houses by a specific date) or targeted efficiency gains.

Part of the Trajectory for Low Energy Buildings (and the NEPP) is a revision of the National Construction Code, which sets efficiency standards for new builds and large-scale renovations. For residential and commercial buildings, energy efficiency provisions were improved in the 2019 NCC revision, with a focus on commercial buildings. In 2022, the NCC was revised to enhance the efficiency standards, with an increase of the mandatory energy performance standards for new residential buildings as of 1 October 2023. Work has begun on the next triennial update of the energy efficiency provisions under the NCC, which is due in 2025 and will again focus on commercial buildings.

Australia has world-class labelling and disclosure schemes and voluntary certification. For example, the Commercial Building Disclosure Program requires energy efficiency information to be provided in most cases when commercial office space of 1 000 m² or more is offered for sale or lease. The programme uses energy ratings provided through the National Australian Built Environment Rating System. However, the one to six rating system does not clarify the number of stars that would indicate the threshold for an efficient building. NABERS energy ratings are available for other sectors, but no disclosure obligation exists. Of the 4 000 participants, 3 000 are commercial office spaces. Extension to other sectors, such as hotels, has been considered, but this has not yet been implemented. Data centres use the NABERS system, but only for their building. No such efficiency measures are imposed on energy-intensive facilities.

Building energy use certification is also available to the housing market through NatHERS for newly built residential buildings. The rating offers a clear incentive for potential buyers and sellers of property to consider energy efficiency characteristics. However, the rating is voluntary, and no disclosure obligation exists. It should be compulsory to show the rating when renting or selling property. Contrary to the six-star NABERS scale, NatHERS has a ten-star rating system and demonstrates compliance with the NCC from a seven-star level. As both schemes have a similar intent, more clarity could be achieved by streamlining the schemes, for instance, with regard to the number of stars.

Several promising improvements to NatHERS have been implemented. The scheme now offers whole-of-home energy assessments (including information about the energy performance of common household appliances) and provides insights into CO_2 building emissions (which is not planned for the NABERS scheme). In the future, an extension of NatHERS to cover existing housing and rental property could enhance retrofitting and provide benefits to tenants. The IEA believes that minimum rental standards (e.g. number of stars) would benefit socio-economically less advantaged groups of the population.

Although the NatHERS scheme offers a stimulus for efficiency measures, the retrofitting challenge is enormous. Due to its voluntary nature and focus on new builds, NatHERS does not (yet) cover the majority of the existing residential building stock. The government estimates that the vast majority of Australian houses would not qualify for more than a two-star rating. Consumers lack information and advice on possible efficiency measures, though they could greatly benefit. The multiple benefits of energy efficiency, such as enhanced living conditions from insulation or lower energy bills, are not adequately communicated and incentivised in the labels/certificates.

States have their own energy efficiency instruments, such as loans, subsidies, energy savings schemes and energy peak demand schemes. The energy savings schemes include white certificates, which in the case of New South Wales is linked to NatHERS. This linkage to NatHERS is an example that if pursued by other states could lead to scale and create a national market for energy efficiency measures.

Contrary to renewable energy, especially solar PV, neither the market demand nor the supply of energy efficiency measures are facilitated in a co-ordinated way and lack sufficient scale (for instance, the European programme Energiesprong). Some suppliers are keen to enter the Australian market and can access funding through the CEFC. However, suppliers will not attempt to enter and remain on the market without any demand. Additional efficiency potential can also be unlocked through greater alignment and co-ordination of energy efficiency policy across all levels of government.

Recommendations

The government of Australia should:

- ☐ Provide clarity on the expected contribution of energy efficiency in achieving the Australian climate ambitions, energy security goals and reducing energy bills, through sectoral energy efficiency and savings targets and a range of support programmes, starting with low-income households.

- Enhance the government's co-ordination leadership role in efficiency by strengthening institutional arrangements (through the creation of an energy efficiency funding programme); better aligning different state initiatives, thereby lowering the cost of transactions; and accelerating the adoption of appliance efficiency, creating markets for energy efficiency and raising awareness of the multiple benefits of energy efficiency on the demand and supply side.
- Unlock the potential of energy efficiency in the household and commercial sector by:
  - Setting a pathway for further raising minimum standards under the National Construction Code.
  - Expanding the coverage and mandatory disclosures of the NatHERS and NABERS schemes, in a similar design, to remaining sectors of the built environment.
  - Designing a national retrofit strategy with appropriate targets and incentives, using international experience of large-scale programmes.
  - Mandatory use of energy certificates when buildings are rented or sold.
  - Adjusting the labelling for clarity, comparability and consistency between the various schemes.
  - Adopting minimum energy and emissions performance requirements, especially in the rental sector.
- Design measures for small and medium-sized enterprises to raise the awareness and capability to utilise their potential for energy efficiency.
- Continue policy and funding efforts to encourage industry and medium-sized energy users to identify and implement cost-effective efficiency measures, for instance, through audits, equipment upgrades, energy management systems, submetering and implementation plans.
- Adopt ambitious fuel efficiency and emissions (CAFE) standards for the transport sector, especially for light vehicles, to reduce emissions in the transport sector and enable the uptake of low-carbon vehicles.

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5. Renewable energy

Key data

(2021)

Renewables in TFEC*: 380 PJ/11.5% of TFEC; (bioenergy** 164 PJ, solar 101 PJ, wind 72 PJ, hydro 43 PJ)

Renewables in electricity generation: 70.4 TWh or 27% of electricity generation (solar 27.7 TWh, wind 24.5 TWh, hydro 14.8 TWh, bioenergy** 3.3 TWh)

Renewables by sector: 22.4% in buildings, 11.1% in industry, 0.8% in transport

Installed generation (2020): 26 GW, forecast IEA: 40 GW by 2030 (base case) or 57 GW (accelerated case)

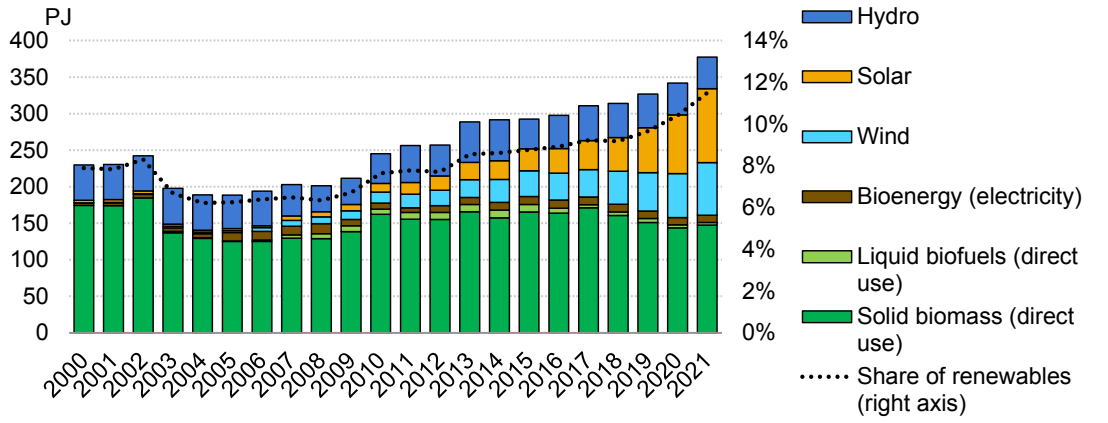
* Total final energy consumption (TFEC) excludes non-energy use, which is counted in total final consumption.

** Bioenergy includes solid biomass and biogas.

Overview

Between 2000 and 2021, the share of renewable energy in Australia's total final energy consumption (TFEC) increased from 8% to 11.5%, mainly driven by the significant growth of distributed solar PV and wind since 2010.

Figure 5.1 Renewable energy in total final energy consumption in Australia, 2000-2021



Renewable energy supply was once dominated by solid biomass, but wind and solar have increased significantly since 2010. This confirms the success of the renewable energy target.

Note: PJ = petajoule.

Source: IEA, (2022a).

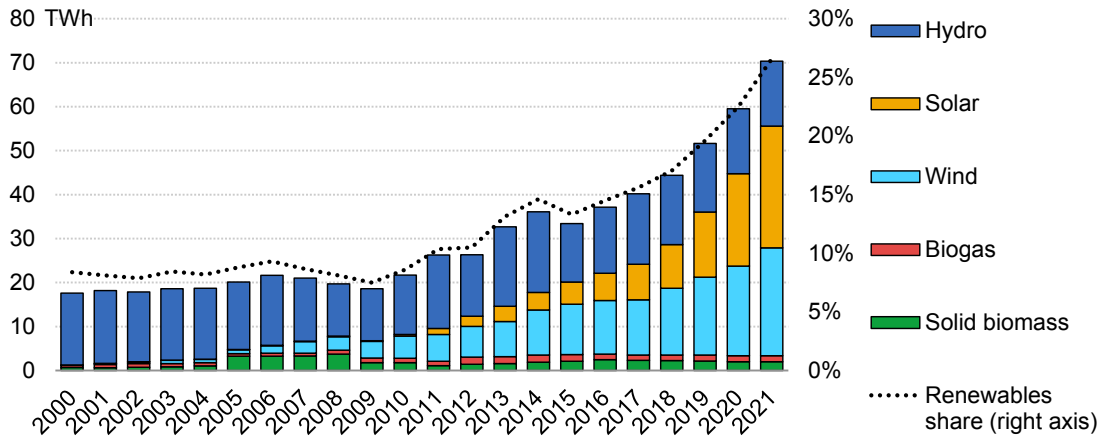
Once biomass covered the largest share of renewable energy in TFEC, accounting for 76% of renewable energy consumption in 2000. But its share is steadily decreasing (reaching 43% in 2021), as variable renewables (VRE) are growing fast.

Solar increased from 3.5 PJ in 2000 to 101 PJ (27% of renewable energy consumption) in 2021, and wind increased from 0.2 PJ to 72 PJ (19%) over the same period. Hydro follows wind, accounting for around 11%, but with a slightly decreasing trend. Solar PV is experiencing the fastest growth thanks to auctions.

Renewable electricity generation

From 2000 to 2021, renewable electricity generation quadrupled, from 17.6 TWh to 70 TWh (Figure 5.2). Over the same period, the share of renewables in electricity generation increased from 8% to 27%. Hydro was the main source of renewable electricity and is fluctuating due to water availability. Electricity generation from hydro has fluctuated since 2000 around an average of 15 TWh. The shares of solar and wind have increased significantly over the past decade. Solar showed a rapid increase, reaching 28 TWh in 2021, when it accounted for the largest share (10.5% of total electricity generation). Wind has also constantly increased, generating 24.5 TWh (9.3%) in 2021.

Figure 5.2 Renewable energy in electricity generation in Australia, 2000-2021



Solar and wind power have increased since 2010 and dominated renewable electricity generation in 2021.

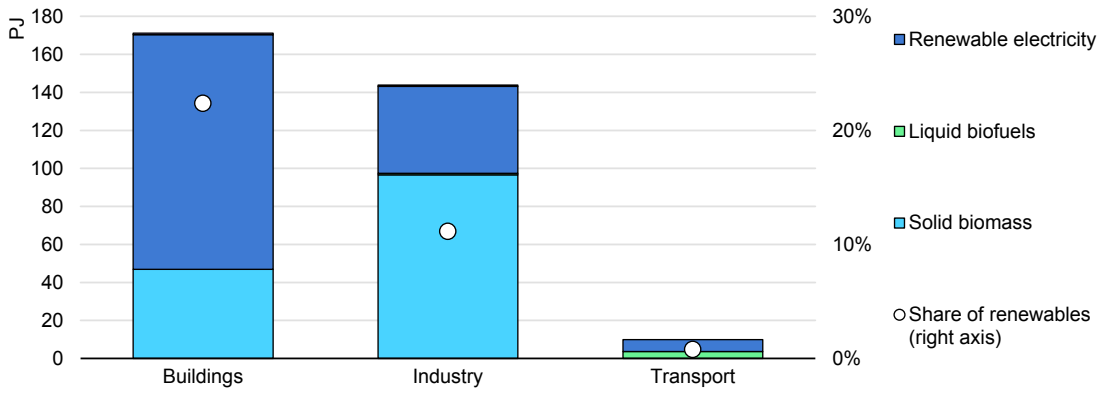
Note: TWh = terawatt hour.

Source: IEA, (2022a).

Renewables by sector

In 2021, renewables covered 22.4% of the energy consumption of buildings, 11.1% of industry and less than 1% of transport. In the buildings sector, renewable electricity covers almost three-quarters of the sector's renewable energy. The remaining renewable energy for buildings came mainly from solid biomass. In the industry sector, solid biomass accounted for over two-thirds of its renewable energy and renewable electricity covered the last third. Renewable energy only accounted for less than 1% of the transport sector, with renewable electricity and liquid biofuels.

Figure 5.3 Renewable energy by end-use sector in Australia, 2021



Renewables covered 22.4% of energy consumption in buildings and 11.1% in industry, but only 0.8% in transport.

Note: PJ = petajoule.
Source: IEA, (2022a).

Renewable energy strategy and targets

Australia's strengthened climate target of 43% of emissions reductions by 2030 provides greater impetus for renewable energy. Moreover, the Australian Government announced its ambition to reach a share of 82% of renewable electricity by 2030 for Australia's national mix. This is in line with the AEMO's Step Change Scenario in the 2022 Integrated System Plan, which forecasts a share of 83% of renewable energy by 2030, in the National Electricity Market.

Renewable energy deployment is driven by states' and territories' targets and auction programmes with reverse auctions and feed-in premiums to meet their own renewable energy targets (Table 5.1). These targets have been upgraded significantly in recent years.

Commonwealth, state and territory energy ministers agreed on the landmark National Energy Transformation Partnership in August 2022 as an integrated energy and emissions reduction agreement. The partnership will serve as a framework for the actions that Australian governments must take to maintain a reliable, secure and affordable electricity system and support the decarbonisation of Australia's energy system. An initial action under the partnership is to introduce an emissions reduction objective into the national energy objectives. The greater collaboration and co-design of policies and strategies include a First Nations Clean Energy Strategy; co-operation on generation and storage adequacy; demand evolution; the identification of transmission projects of national significance through better community consultation; as well as workforce, supply chain and community needs.

Table 5.1 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.

Sources: CCA, (2020) IEA updates.

Permitting of renewables

Australia has seen a reduction in permitting and project lead times (Clapin and Longden, 2022). Before 2016, the average lead time for solar PV projects was 46-85 months. This decreased to 24-40 months between 2016 and 2020 thanks to robust project pipelines and project development experience, high state-level targets, and PPAs driving the expansion of utility-scale solar PV.

Onshore wind projects take longer to develop. Project lead times were 54-128 months before 2005 and decreased to 30-72 months after 2011. While pre-construction lead times decreased for both solar and wind, commissioning lead times decreased for wind projects but increased for distributed solar PV projects, notably due to the introduction of grid fees and higher system costs.

Obtaining a social licence, permits and environmental approvals is essential for completing energy infrastructure projects. The role and name of the National Wind Farm Commissioner were expanded to the Australian Energy Infrastructure Commissioner in March 2021. This role is critical to support local communities and indigenous peoples of Australia (see Chapter 2).

Renewable energy policies

Renewables in electricity

Since its inception in 2001, Australia's federal support scheme for renewable energy is the Renewable Energy Target, a quota system whereby retailers acquire certificates for installing capacity. In 2011, the certificate scheme under the RET was split into the Small-scale Renewable Energy Scheme (SRES) and the Large-scale Renewable Energy Target (LRET), with an objective to reach 41 000 GWh by 2020. In 2015, the ambition was reduced, with an annual target of 33 000 GWh. It is set to end in 2030.

In 2019, Australia reached its 2020 LRET of 33 000 GWh. In 2021, eligible generation under the LRET was 39 000 GWh, exceeding the target by 6 000 GWh. As the 2020 LRET of 33 000 GWh renewable power generation has been reached, the LRET certificate scheme will no longer invite new investment in large-scale renewables, even though certificates can be earned for existing projects until 2030.

By 31 October 2022, 30.1 GW of large-scale renewable energy capacity had been accredited under the LRET and 18.4 GW of small-scale solar PV under the SRES.

Australia's renewable portfolio standard offers retailers the flexibility to reach the targets in the most cost-efficient way with commercial contracts. However, the future success of the RET also depends on the retail market being sufficiently liquid.

Fast-growing renewable energy deployment had a major impact on the system operation and the market design of the NEM. New solar PV capacity has put pressure on the distribution grid due to rising self-consumption and exported power.

The Energy Security Board has carried out extensive regulatory analysis and work on the NEM to integrate the future growth of renewables. This has included introducing renewable energy zones and developing an Integrated System Plan, both of which were

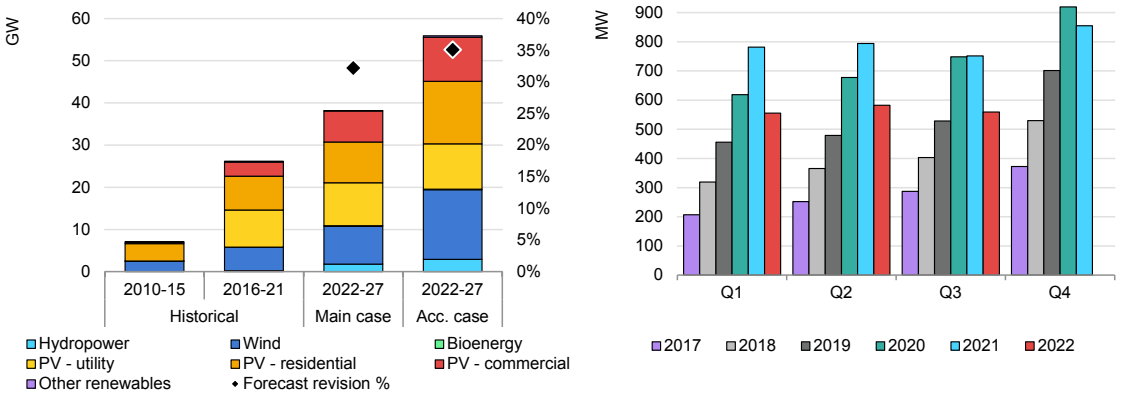
recommendations from the IEA's 2018 review, and is working on an implementation plan to improve the integration of distributed energy resources (DER).

To date, several rule changes have been implemented to support DER integration. They include backstop measures, such as remote disconnection of rooftop solar in emergencies, minimum technical standards to ensure inverter-based DER can withstand voltage disturbances, and access and pricing reform to be more cost-reflective as well as investing in digitalisation. New market rules were introduced allowing distributors to charge for exporting electricity to the grid.

Up to 2027, Australia's renewable energy capacity is forecast to expand by more than 85%, with additions of 40 GW, thanks to the introduction of ambitious targets and increased clean energy funding at federal and state levels, corporate PPAs, and new projects announced in the REZ.

The IEA's latest forecast modelled an accelerated deployment with a higher growth of 57 GW of capacity additions by 2027. This case assumes the faster implementation of the REZ and related grid projects, as well as additional coal retirements and the repurposing of their existing sites with battery storage and renewable energy. This forecast also includes Snowy Hydro adding 2 GW by 2026/27.

Figure 5.4 Australia's renewable capacity additions, 2010-2027 (left) and quarterly distributed PV installation capacity, 2017-2022 (right)



Notes: Acc. case = accelerated case; GW = gigawatt; PV = photovoltaics; MW = megawatt.

Source: IEA, (2022b).

The RET is not able to support offshore wind. Offshore wind is a nascent industry in Australia, and costs are still high, with Victoria and South Australia promoting wind areas. Victoria set targets of at least 2 GW of offshore wind capacity by 2032, 4 GW by 2035 and 9 GW by 2040 under its Offshore Wind Implementation Statement.

The Australian Government announced plans to fast-track the development of an offshore wind industry. The Offshore Electricity Infrastructure Act 2021 entered into force in June 2022. It provides the legal framework to enable the construction, installation, commissioning, operation, maintenance and decommissioning of offshore electricity infrastructure in the Commonwealth offshore area. The Offshore Electricity Infrastructure Regulations 2022 set out detailed arrangements, including the offshore electricity infrastructure licensing scheme, spatial data provisions, arrangements for pre-existing infrastructure, and the application of fees and levies. In 2022, the Energy and Climate

Ministerial Council established a cross-jurisdictional working group, including local government, on the development of Australia's offshore renewable energy industry.

Renewables in heating and cooling

The SRES creates a financial incentive for individuals and small businesses to install eligible small-scale renewable energy systems, which includes solar water heaters and air source heat pumps. Under the SRES, these systems are eligible to receive certificates based on the amount of electricity produced or replaced by the eligible system. According to data from the Clean Energy Regulator, in October 2022, the total number of installations was 423 075 air source heat pumps and 1 059 179 solar water heaters (CER, 2022).

ARENA and the CEFC promote investment in more efficient and renewable energy use in industrial processes, notably solar thermal, geothermal and bioenergy, including biomethane. Funding of fuel-switching projects in the industry can be credited under Australia's Carbon Crediting Scheme.

Renewables in transport

The Australian Government promotes the shift to cleaner fuels and electrification under the Future Fuels and Vehicles Strategy (2021) and the National Electric Strategy, presented in October 2022 for consultation, which includes the introduction of fuel economy standards.

Australia's vehicle fleet is largely petrol-fuelled, but EV deployment is rising, with a steep increase in EV sales in 2021. Between 2018 and 2021, the number of EV sales increased from 2 216 to 20 665. The share of EV sales among total car sales in 2021 was 2%, below the IEA average of 9%. Publicly available charging points have also ramped up since 2018 and were over 3 000 in 2021. In 2021, the EV fleet comprised 34 043 BEVs and 13 701 PHEVs, representing 0.4% of the total car fleet.

Biofuels continue to benefit from excise tax credits. There are no federal biofuel mandates, and the existing grants have been abolished. But there are initiatives on biofuels at the state level, like the Queensland Biofuels Mandate (introduced on 1 January 2017) or the New South Wales Biofuels (ethanol and biodiesel) Mandate (introduced by the Biofuels Act 2007). Major reforms extending New South Wales' biofuel mandate to more (smaller) retail fuel outlets were legislated in 2016 and commenced on 1 January 2017. Obligated fuel retailers must sell 6% ethanol as a proportion of all petroleum product sales. Experience with such mandates has been mixed in terms of customer interest. As biofuel mandates have been strengthened, however, purchases of E10 have declined in New South Wales.

The Commonwealth invested in the construction of a new AUD 500 million renewable diesel and sustainable aviation fuel biorefinery at Gladstone.

Renewables in industry and commercial sectors

The SRES creates a financial incentive for individuals and small businesses to install eligible small-scale renewable energy systems, which includes solar water heaters and air source heat pumps. Under the SRES, these systems are eligible to receive certificates based on the amount of electricity produced or replaced by the eligible system.

Industry in Australia is increasingly investing in renewables for heat processes in the food and manufacturing industry, notably with solar PV projects for self-consumption, but also in the mining and metals sectors as well as for coking production.

Emissions-intensive trade-exposed (EITE) sectors are exempted from the RET. This includes 53 eligible EITE activities as defined in the legislation. Businesses apply to the CER for an exemption for RET-liable electricity used in their EITE activities. The certificate is passed onto the EITE entity's liable entity (usually the electricity retailer) for an agreed value. The responsible entity then uses the exemption certificate to reduce its annual liability.

Assessment

Thanks to declining technology costs, state-based targets and auctions, corporate PPAs, and the Commonwealth's renewables certificate scheme, investment in renewable energy has been growing over the past decade in Australia. In 2021, the share of renewable energy in Australia's total final energy consumption reached 11.5%, mainly driven by the significant growth of solar PV, but also wind. Solar experienced impressive growth, increasing from 3.5 PJ in 2000 to 101 PJ (27% of renewable energy consumption) in 2021, as did wind, which rose from 0.2 PJ to 72 PJ (19%) over the same period.

By sector, in 2021, renewables covered 22% of energy consumption in buildings, 11% in industry but less than 1% of transport. Electricity generation from coal decreased by around 25% from 2010 to 2021 to reach 53% in 2021. It has seen a significant increase in solar and wind. From 2010 to 2021, the average annual growth rate of electricity generation from solar was 31%. It was 13% for wind.

Importantly, renewables contribute significantly to energy consumption in buildings. Australia has the highest installed capacity per capita of solar PV in the world with one in three households with rooftop solar. Australia delivers low and ultra-low-cost solar, notably in the utility-scale segment.

Investors' confidence is further reinforced by Australia's new targets, which provide greater impetus for renewable energy. These targets include the strengthened climate target of 43% of emissions reductions by 2030 alongside the government's goal of reaching a share of 82% of renewable energy by 2030 in Australia's national electricity generation.

The Commonwealth RET and its renewable energy portfolio standard have been the main national scheme. It was capped in 2015 and will end in 2030. Today, there is an oversupply of certificates in the market with low diversity of renewable investment. Outside solar and wind, there hasn't been any significant development of offshore wind, geothermal, biofuels, biomethane, biogas or biomass or other low emissions gases. The RET ends in 2030, and only existing plants can earn certificates. There are methods for biomethane projects under the Australian Carbon Crediting Scheme.

The IEA recommends the government consider specific measures, such as targets to encourage the development of a broad portfolio of renewables and focus on dispatchable renewables, related storage and hybrid renewable investment, which can provide ancillary system services, either via dedicated auctions or an emissions reduction pathway in the NEM. There may be value in expanding the RET to renewable energy gases, including biogas and others and renewable heat in industry, notably for low-temperature heat processes. In December 2022, energy ministers agreed in principle to the Commonwealth

Capacity Investment Scheme, which will underwrite investment in zero emission capacity and storage technologies. There is significant public investment in the sector; for instance, the Clean Energy Finance Corporation allocates roughly 60% of its total budget to renewable energy.

Investment has been strong thanks to ambitious state- and territory-level plans, which have increased targets, auction programmes and support schemes over time. Today, large-scale generation is concentrated in a few states. And many states have very high targets, which have been upgraded even further. The IEA accelerated deployment case forecasts more than 85% growth in renewable energy capacity additions by 2026/27.

The growth of renewables, notably solar and wind power, has a considerable impact on the NEM, which experiences 70-100% instantaneous demand covered by VRE in several regions. The large share of renewables also reduces the economics of baseload coal and gas-fired generation.

System integration of higher shares of VRE requires a comprehensive approach to power system flexibility and adequacy. This includes investment in robust electricity networks, dispatchable generation, demand response and energy storage. The particular challenge of system integration relates to solar PV integration, which requires more battery storage and smart grids. Australia will need to lead globally in the system integration of a rising share of solar PV, with an additional 30 GW of rooftop solar projected to be developed by 2030. The first signs of a slowdown in deployment were visible in 2022, as grid congestion and grid costs can be significant in managing solar PV integration.

The Energy Security Board and the AEMO have made significant progress in adapting the market rules and the system operation to integrate a higher share of renewable energy in the market and system. This includes the introduction of the Integrated System Plan with REZs and expanded scope for essential services and rules for distributed energy resources, all key recommendations from the IEA's 2018 review. The AEMO's Step Change Scenario in the 2022 ISP models the NEM to reach 83% of renewable energy by 2030. The ISP promotes REZs, which, if aligned at the Commonwealth and state/territory level, can create a coherent and system-friendly roll-out, alleviating congestion and overinvestment in transmission. Co-ordinated investment schemes based on the ISP and transmission investment are critical elements of the system integration at the transmission level. Integrating very high shares of renewable energy, however, will require new tools and market rules for a broad-ranging set of flexibility sources and technology innovation, as described in Chapter 7.

Achieving the national 82% renewable electricity target will depend not only on system integration, but also on lifting supply chain constraints and securing the social licence for new infrastructure development, including transmission investment.

The Australian Government aims to promote local manufacturing to overcome supply chain bottlenecks. Developing a renewable energy industrial strategy can indeed help overcome supply chain bottlenecks and support announced ambitions for Australia to become a renewable energy superpower, with significant exports and trade opportunities in Asia.

Project lead times have halved, which is promising for the future deployment of wind. Conversely, a slowdown in growth and an increase in project lead times have emerged for solar PV. The government has an essential role to play in completing electricity

transmission investment across the NEM and the REZs, reducing network congestion in the connection of new renewable capacity while promoting essential system services and the effective integration of distributed energy resources.

Australia is a new market for offshore wind investment, which is not covered by the existing policy framework of the RET. Experience in leading offshore markets in Europe shows that offshore wind targets and auctions are useful policies for bringing down costs and reaching scale, while pre-identified sites, a one-stop shop permitting/licensing regime and the connection by the transmission operator (and not a merchant operator) are necessary tools. Several states have ambitious targets for offshore wind. Commendably, the Australian Government created the legal framework under the Offshore Electricity Infrastructure Act (2021) and related Offshore Electricity Infrastructure Regulations (2022), which are now in force and support spatial planning and permitting. The creation of a cross-jurisdictional working group is an important step towards promoting an offshore energy renewable industry in Australia.

Renewable energy use in industry and transport are areas for further renewables expansion in Australia. Although alternative fuels have been included in government strategies, the share of renewables in transport is negligible and bioethanol did not have much uptake.

While Australia's EV market is expanding, it lags behind other advanced economies and the roll-out is also impacted by major supply chain bottlenecks, notably in battery supply chains. In 2022, Australia had 14.5 million gasoline-fuelled cars and 5.6 million diesel cars.

Biofuels benefit from excise tax credits, but there are no federal biofuel mandates and the existing grants have been abolished. Instead, industry is investing in drop-in biodiesel and sustainable aviation fuel, which can reduce diesel consumption and help decarbonise domestic road transport and aviation. Interestingly, in Europe, biofuel blends are usually less expensive (due to tax rebates for blended fuels and carbon-content based taxation of oil products) and their environmental and economic benefits are appreciated by consumers.

The adoption of CAFE standards, as proposed under the National Electric Vehicle Strategy in 2022, would encourage the roll-out of a broad range of low emissions vehicles, including plug-in hybrids, hydrogen and biofuels, and ensure that Australia can have access to a broad portfolio of low emissions vehicles from the global market.

Recommendations

The government of Australia should:

- Boost the co-ordination of state-based investment schemes, notably through joint planning of renewable energy zones in the National Electricity Market and related auctions and transmission investment under the Australian Energy Market Operator's Integrated System Plan and the National Energy Transformation Partnership.
- Examine scenarios and tools for secure power system operation under very high shares of variable renewable energy in the National Electricity Market regions.

- Boost investment in a diverse renewables technology portfolio by considering dedicated targets for renewable gases, offshore wind and energy storage to boost the overall decarbonisation of the economy.
- Develop a renewable energy industrial strategy aligned with Australia's green superpower ambition preparing actions to boost the development of resilience in supply chains, skills, ports and cybersecurity.

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6. Energy R&D and innovation

Key data

(2021)

Total public energy (RD&D) expenditure: USD 309 million (2021 prices and exchange rates)

Energy RD&D budget as a share of GDP: 0.019% of GDP (IEA average: 0.039%)

Overview

Investment in energy technology development is a core part of Australia's climate strategy. In 2022, Australia legislated a target to achieve net zero emissions by 2050 and a 43% reduction in GHG emissions by 2030 under the Climate Change Act 2022. The related Climate Change (Consequential Amendments) Act 2022 changed 14 other pieces of legislation to focus government institutions on achieving the targets set in the Climate Change Act, notably Australia's funding agencies – ARENA, the CEFC, the CER and CSIRO. This will further strengthen Australia's energy technology investment framework.

Australia has ample availability of clean energy finance and investment and a resilient project pipeline. Over the last ten years, the Australian Government's green bank, the CEFC, has invested AUD 11.14 billion in renewable energy and energy infrastructure (on average AUD 1 billion per year). CEFC funding catalysed a total of AUD 38.65 billion in clean energy investment (CEFC, 2022) in ten years.

However, R&D programmes in energy have been few and have decreased in scope over the past decade. Public funding on energy-related research development and demonstration (RD&D) remained below the IEA average of 0.03%, with a share of 0.019% of GDP in 2021. According to IEA data, public spending on energy RD&D for 2021 stood at USD 309 million or AUD 457 million. The focus has been on commercialising, demonstrating and deploying key renewable and clean energy technologies, such as low-cost solar, wind, energy storage, electrification, energy efficiency and hydrogen.

Australia's know-how, new technology partnerships and multilateral engagement in critical technology and innovation in the clean energy sector have been recognised globally. Australia has been at the forefront of solar research since the 1980s. With one in five solar panels (i.e. PERC) in the world having come from Australian research. The country's new technology partnership approach is a significant driver for international co-operation, notably on hydrogen trade, critical minerals and resilient clean energy supply chains.

Australia has major opportunities from boosting energy-related R&D to accelerate Australia's energy transformation and reach its ambition of becoming a green energy exporter and the development of domestic industries and manufacturing. Powering Australia can pave the way towards a new strategic approach to build an energy RD&D

policy and stronger commitments to public-private partnerships as well as clean energy trade partnerships and climate finance.

Energy innovation priorities and guiding documents[7]

The National Collaborative Research Infrastructure Strategy and related five-year National Research Infrastructure Roadmap, implemented through the biannual Investment Plan, form the overarching planning frameworks for the prioritisation and funding of all research activities across sectors, including energy.

Australia's Climate Change Act 2022 does not explicitly highlight energy RD&D. The National Energy Transformation Partnership, agreed with states and territories in August 2022, includes plans to develop a Clean Energy Strategy for First Nations, among other areas.

Technology and innovation have been at the heart of Australia's climate strategy for the past decade. Building on the Long-Term Emissions Reduction Plan, the former government's Technology Investment Roadmap (2020) set out six priorities for clean energy technology and innovation, with a major emphasis on achieving cost parity, commercialisation and emissions reductions. The former government's road map focused on cross-sector cost breakthroughs in clean hydrogen, energy storage, carbon capture and storage (CCS), ultra-low-cost solar, green steel and aluminium, and measuring soil carbon. Australia's National Hydrogen Strategy was adopted in 2019 under the Council of Australian Governments Energy Council involving all states and territories.

In 2022, the Powering Australia plan set out the key clean energy technologies as solar, wind, energy storage and hydrogen, plus support to help decarbonise hard-to-abate sectors such as cement, construction and agriculture.

In 2021, the Australian Council of Learned Academies advised the government to favour a new strategic approach to an energy RD&D policy in Australia. In consultation with key stakeholders and building on international learnings, the council presented the Australian Energy Transition Research Plan. The plan finds that Australia's performance is very good in science, engineering and technology-related energy research but could be stronger in arts, social science and humanities. However, it notes that a successful energy transition must be more people-centred, focusing on communities' jobs, skills and livelihoods.

To meet the net zero emissions by 2050 ambition, the plan identified key research priorities across three themes: 1) energy system dynamics (transition pathways, technology and systems integration); 2) transition dynamics (policy, social licence and communication); and 3) social engagement dynamics (governance, risks and industry/jobs).

Based on a review of international experience, the Australian Energy Transition Research Plan identified a number of important lessons for Australia on how to build a comprehensive ecosystem for knowledge sharing and research collaboration involving industry and academic partners.

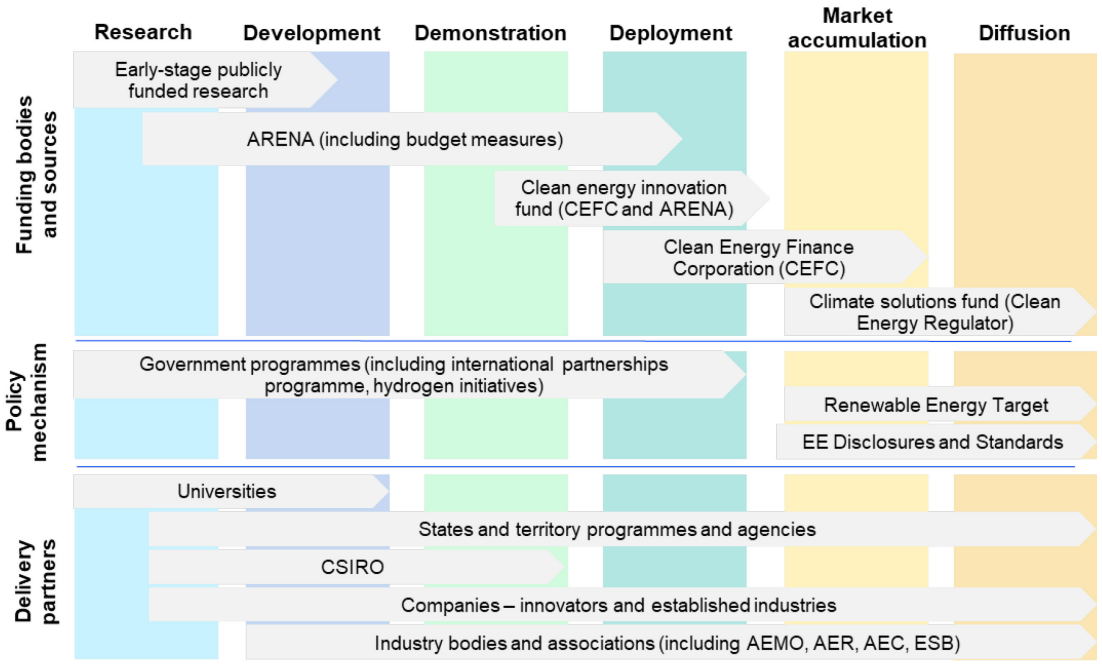
[7] This and the following sections are structured according to the IEA framework for energy innovation policies. Technology innovation processes are complex and decision makers must pay attention to a variety of elements. The IEA groups these elements into four core functions: A) resource push; B) knowledge management; C) market pull; and D) socio-political support. Successful energy innovation ecosystems have effective policies in each of the four areas. In some cases, the policies might operate at different levels, such as local, national or municipal. See: https://www.iea.org/reports/tracking-clean-energy-innovation

The Australian Council of Learned Academies has called on researchers and research funders to refocus the current energy transition research agenda to direct and fund critical research gaps; complement existing strengths and reduce unnecessary duplication; and activate research that will lead to a more sustainable, affordable, reliable and fair future energy system (ACOLA, 2021).

Key actors in the energy innovation ecosystem

Australia's energy technology governance is well established and covers the whole innovation chain (Figure 6.1) from R&D to demonstration and near-commercial deployment.

Figure 6.1 Australia's energy innovation chain, policies, and institutional governance



Notes: ARENA = Australian Renewable Energy Agency; CEFC = Clean Energy Finance Corporation; EE = energy efficiency; CSIRO = Commonwealth Scientific and Industrial Research Organisation; AEMO = Australian Electricity Market Operator; AEC: Australian Electoral Commission; ESB = Energy Security Board.

The Department of Industry, Science and Resources leads Australia's technology and innovation missions for all relevant industries, under the authority of the Chief Scientist, Dr Cathy Foley. The DCCEEW leads, with DFAT, Australia's global engagement on technology partnerships. The DCCEEW has recently created a new division for International Climate and Net Zero Pathways, which links Australian innovation and international engagement and co-operation.

The Australian Research Council is the main funding agency for research grants, ARENA promotes early-stage R&D in renewable energy, energy efficiency and electrification. CSIRO is dedicated to research and analysis and the CEFC, Australia's green bank, promotes commercial investment in renewables, energy efficiency and low emissions technology on behalf of the Australian Government.

AusIndustry is the interface for accessing grants, programme funding and research partnerships for the energy business sector. Australia also has had an R&D tax incentive programme since 2011 (which is not covered under the public RD&D expenditure of the IEA energy RD&D data).

Mirroring the government's technology priorities, CSIRO develops technology road maps and takes a missions-based approach to its research programmes. Its latest missions include the Hydrogen Industry Mission, the Towards Net Zero Mission (transition pathways to embed low emissions technology into Australian industry and agriculture, supporting regional communities in a low emissions future), and the Critical Energy Metals Mission.

CSIRO also provides opportunities for knowledge sharing through online portals, which track and support the development of Australia's technology and innovation capacity. A recent example is for the hydrogen community: HyResource lists 111 industry projects, HyResearch 511 research programmes and HyLearning supports collaboration across the hydrogen R&D knowledge exchange.

Australia has collaborative research centres (CRCs), which include the Race for 2030 CRC, the Future Battery Industries CRC, the Future Fuels CRC, the Heavy Industry Low-carbon Transition CRC and the Future Energy Exports CRC. The Australian Government funds the CRCs with grant funding of AUD 30-70 million over ten years.

In addition, there are many philanthropic organisations and university researchers, including university-based energy-focused research centres and institutes.

Resource push

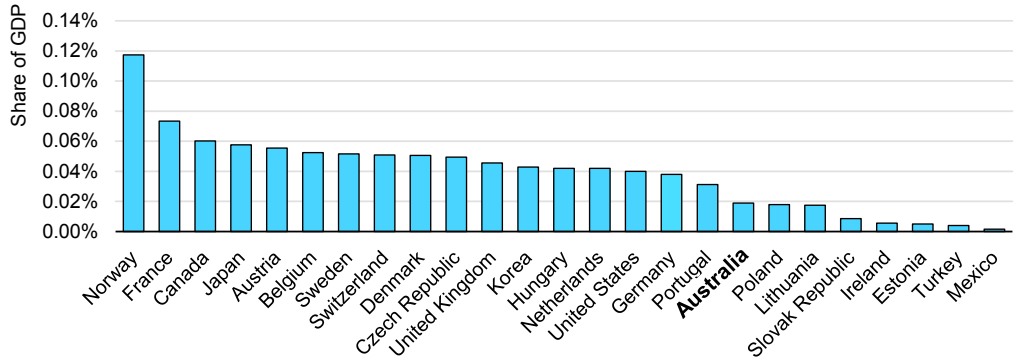
Australia's public funding on energy-related RD&D per GDP, as collected by the IEA, remained below the IEA average (0.039%), with a share of 0.019% of GDP in 2021 (Figure 6.2).

Total government expenditure on clean energy technologies between 2000-01 and 2020-2021 is estimated to be around AUD 21 billion. About 72% of this investment was for commercialisation; only 23% was on R&D and 6% for demonstration.

Government and state-owned energy RD&D budgets peaked in 2013 at USD 839 million, but dropped in 2014 due to major budget cuts. It started to increase again after 2018 to reach USD 309 million in 2021. This also had an impact on the development of new patents for climate-related technologies (see section below and Figure 6.4).

IEA data do not reflect Australia's research and development tax incentive which is an important driver for innovation investment by the private sector.

Figure 6.2 Public budget on energy RD&D per GDP in IEA countries, 2021

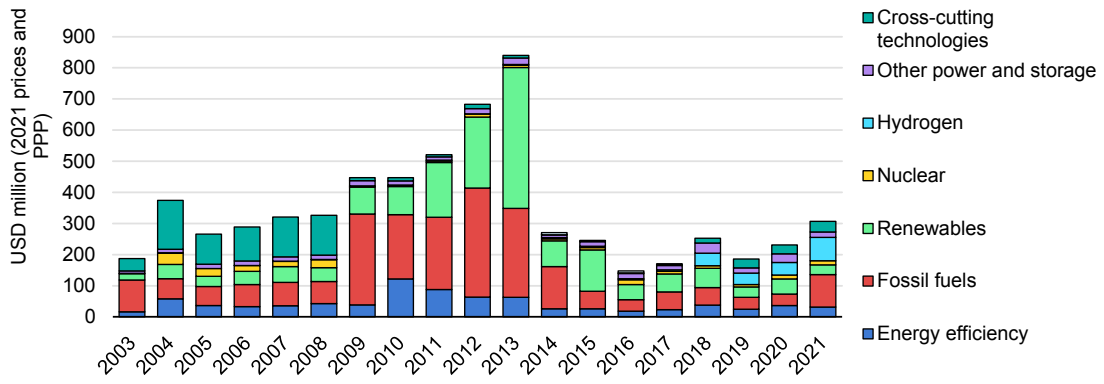


In 2021, Australia's public budget on energy RD&D per GDP was at the lower end of IEA countries.

Notes: GDP = gross domestic product. 2019 data are not available for Greece, Luxembourg or Lithuania.
Source: IEA, (2022b).

In 2021, 34% of the total budget of USD 309 million was allocated to fossil fuels, 25% to hydrogen, followed by cross-cutting technologies (11%), renewables (10%), energy efficiency (10%), other power and storage (5%), and nuclear (4%). Since 2018, Australia has increased its share of the RD&D budget dedicated to hydrogen.

Figure 6.3 Public budget on energy RD&D by sector in Australia, 2003-2021



Public spending on energy RD&D peaked in 2013 before plummeting over the last decade.

Notes: PPP = purchasing power parity. IEA data do not include the commercialisation and finance data nor tax credits.
Source: IEA, (2022b).

With regard to private sector R&D expenditure on energy, the Australian Bureau of Statistics' latest survey reported AUD 857.1 million, representing 4.72% of total Australian business expenditure on R&D in 2019-2020.

Commercialisation

Since its creation in 2012, the CEFC has invested around AUD 11 billion in renewables, grids, energy storage, waste and bioenergy, resources, built environment, and clean tech. In the wind and solar sector, for example, it has financed 42 projects adding 2.1 GW of solar capacity and 1.5 GW of wind. Besides project finance, the CEFC has also invested in four of Australia's infrastructure asset funds (CEFC, 2022).

In 2022, the government announced a capital increase of AUD 11 billion to the CEFC to realise investment in grids and grid-related clean electricity infrastructure as part of the Rewiring the Nation initiative. This would be the first new capital to the CEFC in its ten-year history. Battery storage and hydrogen are the CEFC's key future investment areas alongside the AUD 500 million Powering Australia Technology Fund and leveraging AUD 500 million in private investment as a CEFC equity vehicle.

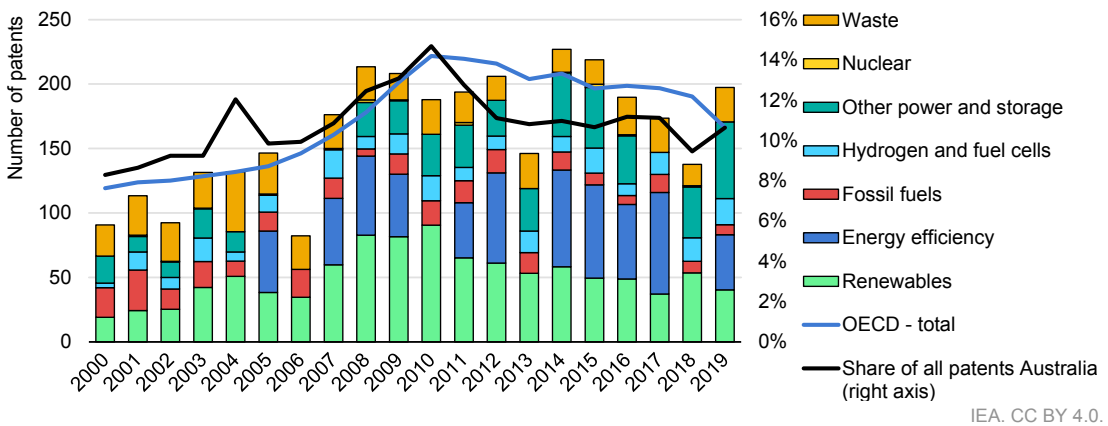
Since 2012, ARENA has supported 632 projects with AUD 1.96 billion in grant funding, which leveraged a total investment of AUD 8.81 billion in Australia's renewable energy industry (or AUD 1: AUD 3.48). ARENA provides grant funding for renewable energy projects across the innovation chain, from applied research to pre-commercial deployment. In 2022, the Australian Government expanded ARENA's functions to include the provision of support for energy efficiency and electrification technologies and grids.

In 2022, the government announced the National Reconstruction Fund, with the stated objective of providing finance for projects that diversify and transform Australia's industry and economy. The AUD 15 billion National Reconstruction Fund will allocate around AUD 3 billion to renewables and emissions reduction technologies.

Knowledge management

In 2019, the share of climate-related patent applications in all technologies followed the OECD trend, growing at the beginning of the decade and slightly declining afterwards.

Figure 6.4 New patents in clean energy technologies in Australia, 2000-2019



Australia's new patents were oriented towards clean energy technologies in 2019.

Source: OECD, (2022).

Over the past decade, Australia's share of climate-related patent applications in all technologies has been similar to the OECD average (Figure 6.4), on a falling trend since its peak in 2010. New patents in climate change mitigation technologies were 10% of all patent applications in 2019, compared to 9% in the OECD.

International collaboration

The Australian Government is working closely with international partners to advance practical action on climate change and build new clean energy industries. The government's bilateral international clean energy partnerships are focused on advancing technology collaboration, building new clean energy trade opportunities, and scaling and diversifying clean energy supply chains. Since 2021, Australia has established international clean energy partnerships with Germany, India, Japan, Korea, Singapore, the United Kingdom and the United States. At the multilateral level, Australia is a leading technology partner in energy systems and grid integration of renewables, critical minerals, hydrogen, CCUS and ammonia.

In 2017, the Australian Government announced a one-off AUD 5 million International Engagement Programme delivered by ARENA to create international collaborations and to participate in projects under Mission Innovation and the IEA's technology collaboration programmes (TCPs).

In 2021, the government committed AUD 500 million to strategic international partnerships that support projects that advance practical action on climate change, including accelerating the development and deployment of new energy technologies (such as hydrogen, green steel and energy storage). This funding envelope compares to the AUD 300 million the government allocated to energy RD&D funding in 2021. Australia has invested over AUD 10 million on designing a world class hydrogen guarantee of origin scheme, as it was also leading the working group at the IPHE on an international scheme.

In 2022, Australia participated in 22 of 39 IEA TCPs, with representatives from government agencies, industry specialists and research institutions. Australia strongly supports TCPs on renewable energy, hydrogen and fossil fuel-related technology activities, as well as several energy efficiency/end-use activities (Table 6.1).

Table 6.1 Australia's participation in IEA technology collaboration programmes

Technology collaboration programmes (TCPs)	Contracting parties
Cross-cutting	**2**
Clean Energy Education and Empowerment (C3E TCP)	DCCEEW
Energy Technology Systems Analysis (ETSAP TCP)	CSIRO
End-use: Buildings	**2**
Energy Efficient End-Use Equipment (4E TCP)	DCCEEW
Buildings and Communities (EBC TCP)	DCCEEW

Technology collaboration programmes (TCPs)	Contracting parties
End-use: Electricity	**2**
User-Centre Energy Systems (USERS TCP)	University of New South Wales, Monash University
Smart Grids (ISGAN TCP)	CSIRO
End-use: Industry	**0**
End-use: Transport	**1**
Advanced Materials for Transportation (AMT TCP)	Curtin University
Fossil fuels	**4**
International Centre for Sustainable Carbon (ICSC TCP)	Australia National Low Emissions Coal Research & Development, Department of Industry, Science and Resources
Enhanced Oil Recovery (EOR TCP)	Department of Premier and Cabinet (South Australia)
Gas and Oil (GOTCP)	CSIRO
Greenhouse Gas R&D Programme (GHG TCP)	CSIRO
Fusion	**3**
Plasma Wall Interaction (PWI TCP)	Australian Nuclear Science and Technology Organisation, Australian National University
Stellarator-Heliotron (SH TCP)	Australian National University
Tokamak Programmes (CTP TCP)	Australian Nuclear Science and Technology Organisation
Renewable energy and hydrogen	**8**
Bioenergy TCP	Bioenergy Australia, University of the Sunshine Coast
Concentrated Solar Power (SolarPACES TCP)	ITP Renewables
Geothermal Energy (Geothermal TCP)	Department of Energy and Mining (South Australia)
Hydrogen TCP	Curtin University, Griffith University
Hydropower TCP	Hydro Tasmania
Ocean Energy Systems (OES TCP)	CSIRO, Australian Marine Energy Taskforce
Photovoltaic Power Systems (PVPS TCP)	Australian PV Institute, Sustainable Energy For ALL
Solar Heating and Cooling (SHC TCP)	Sustainable Energy Transformation Pty. Ltd., CSIRO
TOTAL	**22**

Notes: DCCEEW = Department for Climate Change, Energy, the Environment and Water; CSIRO = Commonwealth Scientific and Industrial Research Organisation; PV = photovoltaics.

Australia also participates in the Mission Innovation initiative to accelerate global clean energy innovation. Australia co-leads Mission Innovation's Hydrogen Mission and the new Net Zero Industries Mission, which aims to demonstrate at least two low emissions technologies for all major heavy industry sectors by 2030.

Under the Clean Energy Ministerial (CEM), Australia co-leads the new Transforming Solar Supply Chains initiative and is a member of the CEM Hydrogen Initiative (H2I), increasing links with the International Partnership for Hydrogen and Fuel Cells in the Economy and Mission Innovation. Australia is also a member of the Carbon, Capture, Utilisation and Storage Initiative.

In July 2022, the Australian Government and the IEA co-hosted the Sydney Energy Forum jointly with the Australian Business Council. One of the major outcomes of the forum was an agreement to boost collaboration on energy RD&D needs in the Indo-Pacific region. This supports the energy transition in the Indo-Pacific, clean energy technologies and critical clean energy supply chains; enabling markets, capabilities and structures, notably for solar PV and battery technologies, critical minerals and gigafactories needed to produce them in Australia, and the development of hydrogen supply chains to export clean energy across the region. The forum was initiated by the prime minister of Australia, with support from Prime Minister Modi, President Biden and former Prime Minister Suga.

Market pull

Australia is focused on creating economic added value by transforming its mineral resources into higher value products for exports, creating manufacturing jobs and export-ready technologies, notably in hydrogen, ammonia, green metals and renewables, and critical minerals.

Hydrogen

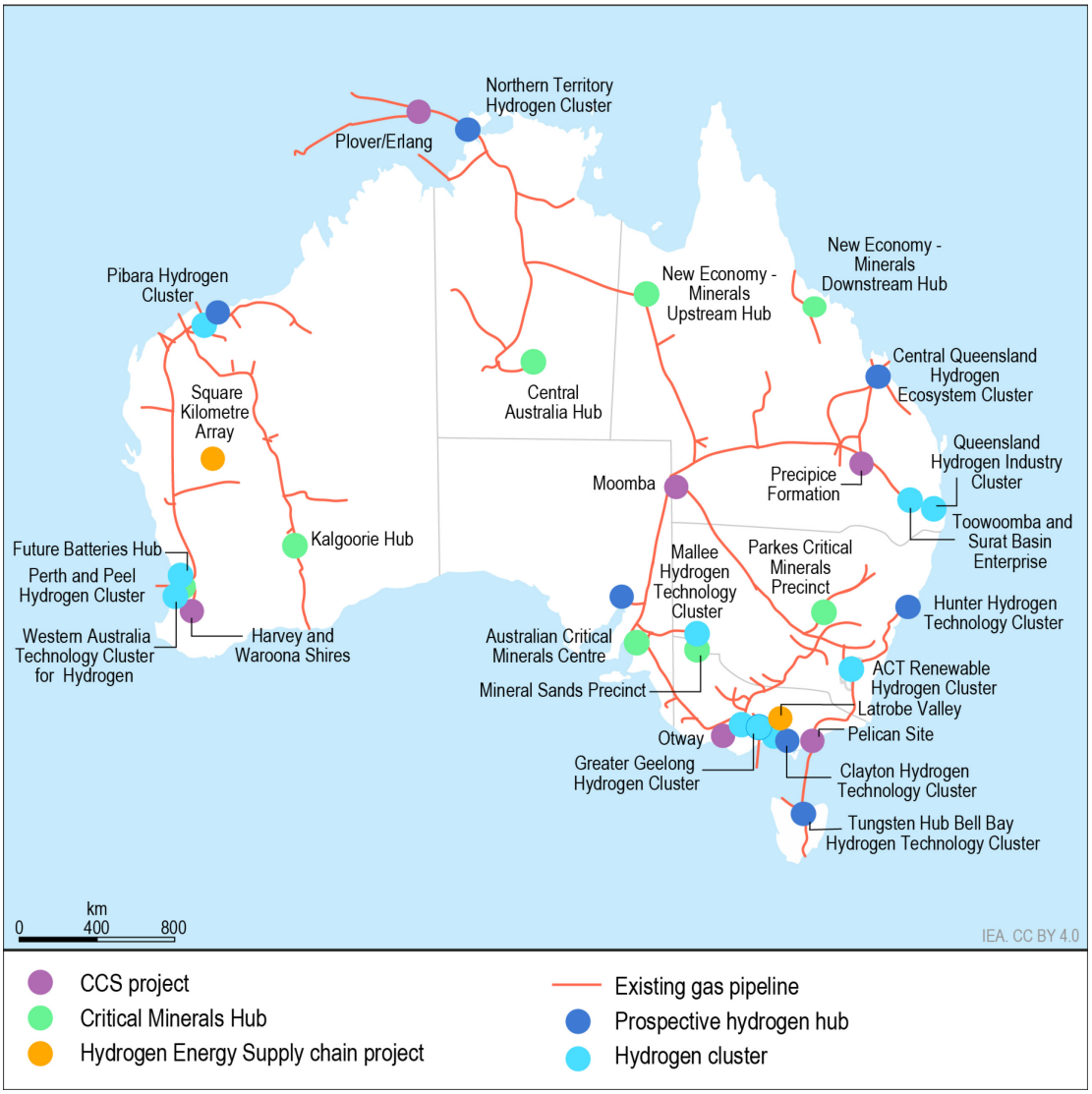
The National Hydrogen Strategy of 2019 aims to build a clean, innovative, safe and competitive global hydrogen sector in Australia. It set in motion an industrial programme with strong international partnerships.

In 2022, Australia ranked second globally behind Europe in electrolyser capacity projects expected to come online by 2030 (IEA, 2022c). Australia's Hydrogen Energy Supply Chain (HESC) project was the first in the world to ship hydrogen from Hastings, Victoria to Kobe, Japan in January 2022. After the demonstration phase with unabated coal, in its second phase, HESC will be shipping low-emissions hydrogen production using CCUS.

Exports projects proposed in the area of low-emission hydrogen would entail the installation of 120 GW of new renewable energy projects. These projects include the Australian Renewable Energy Hub (26 GW), Yara Pilbara (5 GW), Province HyEnergy (8 GW), Murchison Renewable H2 (5 GW), Infinite Green Energy (1 GW), the Western Green Energy Hub (50 GW), Fortescue Future Industries (2 GW), Stanwell (3 GW), the Hydrogen Utility (3 GW) and the proposed Australia-Asia Power Link (AAPowerLink) (20 GW).

Thanks to ample and low-cost solar and wind with major Asian demand centres within reach, Australia's hydrogen production from renewable electricity could reach 3 million tonnes of hydrogen by 2030 based on the project pipeline, corresponding to an electrolyser capacity of nearly 50 GW. Some challenges arise with supply chain issues, scalability (Australia does not have offshore wind yet) and the climate of Australia: South Australia's electrolyser project with 6 GW of renewable electricity supply was cancelled in 2022 due to water supply concerns. Australia's LNG terminals are good locations to also deal with hydrogen exports and many demonstration projects are underway (Gladstone).

Figure 6.5 Hydrogen and CCS clusters and hubs across Australia



Note: CCS = carbon capture and storage.

Source: IEA, (2022).

Table 6.2 Operational low-emission hydrogen projects in Australia

Project name	Commissioning date		
ATCO clean energy innovation hub	2019	PEM	Grid (excess renewable)
Sir Samuel building Griffith Centre, Brisbane	2013	ALK	Other/unknown
Hydrogen Park South Australia – HyPSA	2021	PEM	Dedicated renewable
Jemena Western Sydney – H2GO project	2021	PEM	Grid
Toyota Hydrogen Centre, Altona, Victoria	2021	Other electrolysis	Grid (excess renewable)
Canberra HRS	2021	PEM	Dedicated renewable
4 projects of ITM in Australia	2018	PEM	Other/unknown

Notes: PEM: proton exchange membrane; ALK: alkaline.
Source: IEA, (2022d).

Carbon capture and storage

Australia was an early leader in CCS. It created a dedicated regulatory framework and is home to the world's largest dedicated CO_2 storage facility, located at the Gorgon LNG plant. Several projects are in advanced stages of development, including the Moomba CCS project that reached final investment decision (FID) in 2021 and is now in construction. CCS is now an eligible technology under the Australian Carbon Crediting Scheme (formerly the ERF). Under its own method, CCS projects can earn credits for every tonne of emissions reduced or stored. There is no method for CCUS.

Australia is well-suited to large-scale deployment of CCS to facilitate domestic CO_2 abatement and support regional emissions reductions. The Australian Government is taking a pragmatic approach to achieving meaningful emissions reductions and is interested in all viable technologies, including CCS, to ensure Australia meets climate targets. Australia is seeking to implement frameworks that will provide certainty for industry and like-minded countries to invest and deploy abatement technologies such as CCS.

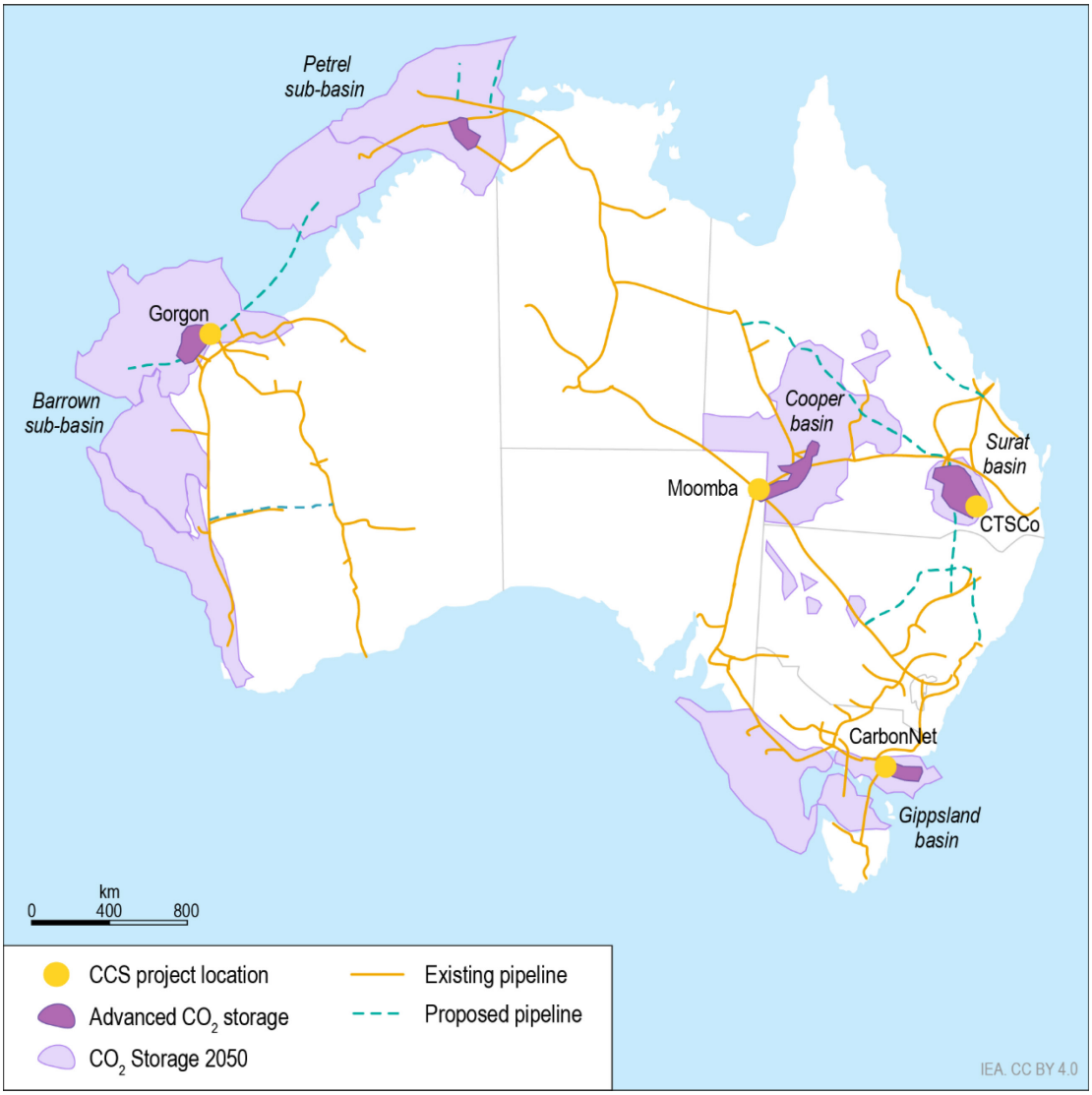
To date, the Australian Government has predominantly used grants (over AUD 850 million since 2009) to support the development and deployment of CCS technologies and fund pre-competitive geological storage data acquisition and studies (which are made freely available) to attract investment into Australia. This comprehensive and high-quality pre-competitive data offers significant competitive benefits for Australia.

Grant funds have been limited to pre-commercial activities, and grants alone tend to be insufficient to sustain CCS projects to deployment. Instead, grants have sought to facilitate

early phases of project development, such as pre-commercial front-end engineering design studies, site exploration or demonstration-scale projects.

The Australian Government recently announced the establishment of a new Carbon Capture Technologies Program to support the accelerated development of novel carbon capture and carbon utilisation technologies by way of supporting RD&D projects. The programme will commit AUD 130 million over nine years from 2022-2023 to 2030-2031 and is expected to launch in early 2023. In addition, CCS is now an eligible technology under Australia's Carbon Crediting Scheme. As a result, CCS projects can earn credits for every tonne of emissions reduced or stored.

Figure 6.6 Storage and carbon capture and storage projects across Australia



Note: CCS = carbon capture and storage.
Source: IEA, (2022).

Australia has around 16 commercial CCS projects in operation or development, notably:

Gorgon CO_2 Injection Project: This project is located at Barrow Island (north-west coast of Western Australia) and is Australia's only commercial-scale project geologically sequestering CO_2. Operated by Chevron Australia, at full operation, the facility can capture up to 4 Mt CO_2 per year from natural gas processing. The project has stored over 7 Mt CO_2 since it commenced injection in August 2019.

Carbon Transport and Storage Company Surat Basin CCUS Project: This project aims to demonstrate the viability of industrial-scale CCUS in Queensland, within a Surat Basin hub, capturing and storing emissions from multiple generators and other industrial sources.

Santos Moomba CCS Project: This project is located in South Australia's Cooper Basin and aims to safely and permanently store 1.7 Mt CO_2 per year in the same reservoirs that held oil and gas in place for tens of millions of years. Capture is from natural gas processing, with plans to test direct air capture technologies at the site. The project is expected to become operational in 2023.

CarbonNet Project: CarbonNet aims to provide a decarbonisation solution to emitting industries in the Latrobe Valley by transporting CO_2 via a shared infrastructure pipeline for geological sequestration in the Gippsland Basin. CarbonNet's CCS Hub will cater to both existing and emerging emitters in the Latrobe Valley and provide a shared offshore storage service to a range of industries, including hydrogen and fertiliser production, natural gas, waste to energy, and negative emissions through bioenergy with CCS and direct air capture.

Monitoring, evaluation and tracking of results

The Annual Climate Change Statement will be carried out annually and update parliament and the wider public on Australia's progress. It is a good tool for developing a tracking and evaluation framework for R&D and innovation spending and progress, including in international collaboration and net zero partnerships.

The CEFC and ARENA regularly review progress and funding instruments. ARENA has recently reviewed the Renewable Energy Venture Capital Fund in advance of the recent discontinuation of ARENA's management of the fund.

Assessment

Australia has focused to date on developing commodities for export but has not yet used its opportunities for developing energy technology for exports. Australia is well placed to do so with its strong governance for energy research, development and demonstration across the technology innovation chain (technology readiness levels). ARENA promotes early-stage R&D while the CEFC, Australia's green bank, promotes commercial investment in renewables and energy efficiency. At the international level, the government is focused on developing innovation partnerships for achieving net zero economies with global trade partners. However, developing a strategy that creates such export opportunities will require a strategic push.

The government made energy technology and innovation a key plank for meeting the country's climate goals and for the country's industrial and economic opportunities but has not provided the funding or the strategy to reach these export markets. To date, there is

no strategy or coherent national approach across the government for energy RD&D needed in Australia for the domestic market and its domestic energy transition. Energy efficiency in the built environment and smart grids and digitalisation in the energy system have been largely underfunded.

By international comparison, many green banks have dedicated large-scale energy efficiency programmes, such as the German KfW or the European Investment Bank. These banks have also been leveraged to accelerate economic recovery from the Covid-19 pandemic and recently to fund an accelerated energy transition in the context of the global energy crisis. The CEFC could play a more significant role in this area in the future, together with ARENA's grant programmes. Notably, the combination of renewable energy projects and energy efficiency renovations have ranked high in global economic recovery programmes.

Recently, the Australian Government has raised the importance of creating manufacturing and economic opportunities, not only in EVs and batteries but also in processing critical minerals to avoid overdependence on international supply chains. This is an opportunity for the Australian Government to refocus on its approach and consider a new strategy for energy RD&D, identifying areas for new patents and clean energy start-ups. The Australian Council of Learned Academies has set out an Australian Energy Transition Research Plan. This should be taken into account as the government forms its net zero policy packages and annual tracking of emissions targets under the Annual Climate Statement. The annual tracking of technology and innovation impacts, funding, and outcomes should form an integral part of the Annual Climate Change Statement to Parliament, as set out in the Climate Change Act 2022.

The AUD 15 billion National Reconstruction Fund will allocate around AUD 3 billion to clean energy and emissions reduction technologies. However, the energy transition towards net zero emissions by 2050, as set out in the updated NDC, does not explicitly link technology and innovation. The National Energy Transformation Partnership, agreed with states and territories in August 2022, does not explicitly link the energy RD&D needed for Australia's energy transition.

To drive the implementation of its net zero goal, the government should strengthen the collaboration of the Department of Industry, Science and Resources; DFAT; and the DCCEEW. This should bring together energy RD&D efforts towards the NDC implementation and net zero innovation. The creation of the new International Climate and Net Zero Pathways Division and its Net Zero Innovation and Partnerships team in the DCCEEW is a very positive step in this regard.

While there is no general lack of finance in Australia, energy funding efforts are fragmented across government at federal and state/territory levels and across the value chain. Greater impact could be gained from consolidating these efforts across government, notably on early-stage energy research.

Since its inception in 2021, the CEFC has invested over AUD 11 billion. Since 2012, ARENA has provided AUD 1.96 billion in grant funding, which leveraged a total investment of AUD 8.81 billion in Australia's renewable energy industry. To date, Australia has strongly focused on commercialisation, as the latest data illustrate. Out of total government expenditure of around AUD 21 billion on low emissions technologies (2000-2001 to 2020-2021), about 72% was for commercialisation, 23% for R&D and 6% demonstration.

Private sector R&D expenditure on energy is also significant. The Australian Bureau of Statistics' latest survey shows a total of AUD 857.1 million, representing 4.72% of Australian business expenditure on R&D in 2019-2020.

Australia's public spending allocated to energy RD&D has been much smaller in scope and funding than the IEA average. In 2021, Australia's budget on public expenditure on energy-related RD&D amounted to 0.019% of GDP, half of the IEA average. The public energy RD&D budget peaked in 2013 at USD 840 million, dropped from 2014 to 2016, and increased again after 2018 to reach USD 309 million in 2021. In the same year, 34% of the total budget was allocated to fossil fuels, 25% to hydrogen, 11% to cross-cutting technologies, 10% each to renewables and energy efficiency, 5% to other power and storage, and 4% to nuclear. Since 2018, Australia has increased its share of the RD&D budget dedicated to hydrogen.

Nevertheless, energy RD&D funding by ARENA and the CEFC does not yet match the government's ambition for reaching net zero emissions by 2050. The IEA estimates that, on a path toward net zero emissions by 2050, many technologies already exist today but need to be scaled up. Governments need to invest today in the development and demonstration of the most critical technologies needed by 2050. This is notably true for the hard-to-abate sectors, where demonstration has to start before 2030. The Australian Government should refocus its funding programmes.

Across all sectors, Australia offers a R&D tax incentive programme (since 2011) and an investment rebate which limits the tax burden of revenues gained from investment in start-ups. The Australian Research Council is Australia's main funding agency for research grants. CSIRO is dedicated to working with industry and government on technology R&D, analysis and technology roadmaps. However, CSIRO covers the entire economy and the energy technology and innovation focus could be boosted by building on existing funding and expanding collaboration with the DCCEEW and international partners.

While clean energy finance is available in Australia, there appears to be a lack of capital for riskier investments and insufficient venture capital for the energy sector, with a gap in early-stage development and access to research collaborations, such as co-operative research centres and ARENA for start-ups and academia/universities.

The government should support global energy RD&D partnerships for Australian start-ups by enhancing the university research landscape, collaboration with business, and start-ups and spin-offs. Since 2012, Australia's share of climate-related patent applications in all technologies has been like the OECD average. New patents in climate change mitigation technologies were 10% of all patent applications in 2019, compared to 9% in the OECD.

The government needs to strengthen market-pull frameworks, align supportive government policies, identify and lift regulatory barriers, and ensure there are policies to support the creation of new clean energy markets. This applies to the hydrogen supply chain where a blending framework would be useful, alongside regulations around the availability of water and low emissions fuel standards. For example, the absence of CAFE standards has hampered technology innovation in low emissions vehicles and alternative fuels. Equally, the absence of NEM-wide rules on distributed energy and demand response limits the scale of smart energy roll-out.

Australia is currently working on a range of policy settings and technologies to help reduce its emissions, adopting a pragmatic, evidence-based approach to achieve real emissions

reductions with all technically and economically viable technologies playing a role. Some of the challenges Australia faces include: the development of economic drivers that entice industry uptake of CCUS technology (like direct air capture) and attaining a deeper understanding of Australia's onshore and offshore geological storage potential to support future planning and attract investment; and demonstrating the social value of CCUS of its potential and versatility.

The Australian Government is in a unique position to promote offshore wind deployment, transmission and related hydrogen/electrolyser, including in current petroleum production areas. The petroleum licensing regime does not allow for the operation of renewable energy on site, such as floating wind power. Electrification of LNG production processes would, however, be an interesting opportunity not only for boosting local manufacturing but also for emissions reductions. The government should seek to amend the rules as necessary to include CCUS in Australia's Carbon Crediting Scheme and facilitate the use of renewable energy at offshore production sites.

On hydrogen, Australia is taking the lead in developing global hydrogen trade. In 2022, it came second after Europe in electrolysis investment. Australia was an early leader in demonstrating CCS technology and adopting the regulatory framework. CCS could support export opportunities for low-carbon hydrogen in Australia, with a pilot study underway in Victoria using lignite to produce hydrogen for export to Japan. Australia is home to the world's largest dedicated CO_2 storage facility, located at the Gorgon LNG plant, and several projects are in the advanced stages of development. While Australia has strong plans, strategies and targets for boosting low emissions hydrogen and CCS, it will reduce its global reach if it does not promote a domestic market. Market-pull policies are therefore critical and dedicated strategies and implementing frameworks must be finalised. A low emissions gases regulatory framework would support the industrial opportunities within Australia.

At the international level, Australia is a partner in bilateral and multilateral technology co-operation. Since 2021, Australia has had around ten bilateral energy technology partnerships with the leading markets for low emissions technologies development, including Germany, India, Japan, Singapore, the United Kingdom and the United States. In 2022, Australia participated in 22 of 39 IEA technology collaboration programmes, notably on renewable energy, hydrogen and fossil fuel-related technology activities but also several energy efficiency/end-use activities. In addition, Australia co-leads Mission Innovation's Hydrogen Mission as well as the new Net Zero Industries Mission.

Under the Clean Energy Ministerial, Australia co-leads the new Transforming Solar Supply Chains initiative and participates in the CEM Hydrogen Initiative. In addition, it is a member of the CEM Carbon, Capture, Utilisation and Storage Initiative.

Recommendations

The government of Australia should:

- ☐ Design a cross-government energy research, development and innovation strategy for developing economic opportunities in Australia and for exports, underpinned by funding programmes and global collaboration.

- In the context of the Annual Climate Change Statement, track the impacts of public and private funding of energy RD&D across critical clean energy technology priorities.
- Analyse clean energy supply trade opportunities and supply chain bottlenecks while boosting the creation of national clean energy markets and international partnerships, notably in the Indo-Pacific region.
- Open up the research landscape for technology innovation and start-ups by reducing barriers to access, increasing opportunities for start-ups to reach international partners/markets, and increasing access to venture capital, including in overseas markets.
- Strengthen collaboration across government and agencies (Department of Climate Change, Energy, the Environment and Water; Department of Foreign Affairs and Trade; and Department of Industry, Science and Resources) involving the broad sector stakeholders.
- Update the offshore petroleum licensing regime to allow for the production of hydrogen (related carbon capture, utilisation and storage applications) and offshore wind as opportunities for boosting local manufacturing and alleviating global clean energy supply chain issues.
- Create an energy transition technology and innovation platform for dialogue across Australia's energy research community and industry.

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7. Electricity

Key data

(2021)

Electricity generation: 265 TWh; +5% since 2011 NEM: 203 TWh

Electricity generation mix: coal 52.9%, natural gas 18.8%, solar 10.5%, wind 9.3%, hydro 5.6%, oil 1.8%, bioenergy and waste 1.3%

Electricity consumption: 239 TWh (industry 43%, residential buildings 27%, service sector buildings 27%, transport 3%); +6% since 2011

Peak load (2020): 41.9 GW

Installed capacity in Australia (2022): 86.7 GW (29% variable renewables), NEM: 65 GW

Overview

The Australian Government is progressing with a number of new reforms as part of its Powering Australia plan. The government presented plans to reach a share of 82% of renewables in Australia's electricity mix by 2030. The system operator AEMO forecasts a share of 83% of renewable energy by 2030 would be aligned with the government's goal of a 43% emissions reduction by 2030 (from 2005 levels) in the effort to achieve net zero emissions by 2050, as enshrined in the Climate Change Act 2022.

In August 2022, energy ministers committed to a new National Energy Transformation Partnership. The partnership will serve as a framework for the actions that Australian governments must take to maintain a reliable, secure and affordable electricity system and support the decarbonisation of Australia's energy system. Reforms to the NEM structure, its governance and reliability settings, as well as the reforms to the domestic gas market, are progressed alongside a stronger focus on consumers and demand-side action.

Since the last IEA review, the Australian Government has been implementing measures to manage the integration of variable renewable energy into the electricity system, as conventional coal-fired power plants are being retired faster than anticipated. Progress has been guided by the AEMO's ISP and supported by key reforms, including the introduction of the five-minute settlement and new market rules for ancillary services, as proposed by the AEMC.

The government is placing strong focus on Rewiring the Nation, an initiative to advance the electricity interconnections and bolster grids to handle more renewable power reliably. Australia's energy infrastructure and system must withstand ever more significant extreme weather events, such as bushfires, floods and heat waves.

To ensure adequate firming capacity in the NEM jurisdictions to back up fast-rising variable renewables, the Australian Government, states, territories and the market bodies have worked together to introduce a series of "Post-2025" NEM reforms across four key reform pathways: 1) resource adequacy mechanisms and ageing thermal retirement; 2) essential system services and scheduling ahead mechanisms; 3) effective integration of distributed energy and flexible demand; and 4) transmission and access reform. In December 2022, energy ministers agreed to the Commonwealth Capacity Investment Scheme, which will underwrite zero emissions capacity and storage technology.

Due to the global energy crisis, a result of Russia's invasion of Ukraine and its impact on global energy markets, Australia has seen a period of sustained high wholesale electricity prices, driven in part by high coal and natural gas prices. The AEMO suspended the spot market in all regions of the NEM between 15 and 24 June 2022 as the market could not continue to operate effectively and ensure a secure and reliable supply of electricity for consumers. High fuel costs have led to increasingly high price volatility, inflationary pressures and rising household bills. The Australian parliament passed legislation in December 2022 to cap coal and gas fuel prices as a short-term emergency measure for 12 months. The law caps the domestic gas price at AUD 12 per gigajoule (GJ). It also limits domestic coal prices to AUD 125 Australian per metric tonne in the states of New South Wales and Queensland.

Electricity generation

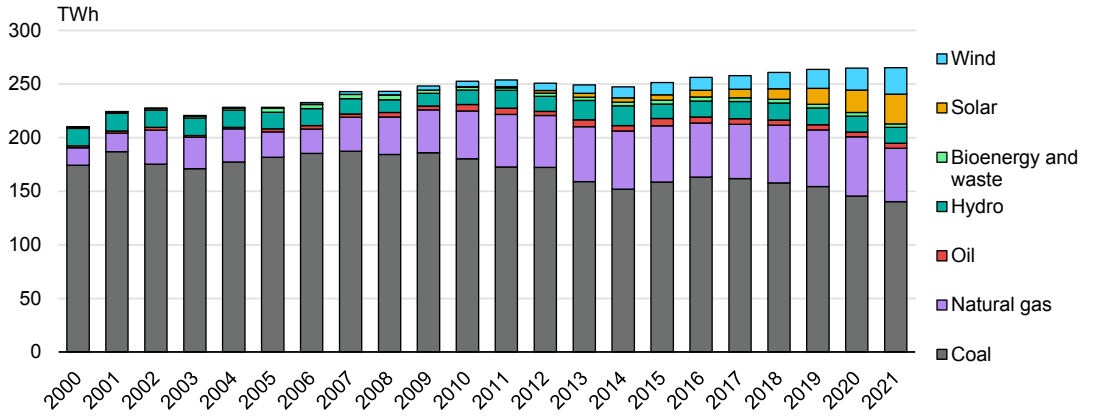
Installed capacity

In 2020, Australia had a total installed capacity of 86.7 GW, of which 29% was coal and 28% natural gas. This compares to a peak demand of 41.9 GW. The installed capacity of hydro has remained stable, but solar PV has accelerated quickly.

Australia's electricity generation is heavily reliant on coal and natural gas, although the role of coal in electricity generation is gradually decreasing and is being replaced by renewable energy sources. Total electricity generation in 2021 was 265 TWh, a 5% increase since 2010. In 2021, coal covered 53% of total generation, followed by natural gas (19%), solar (10.5%), wind (9%), hydro (6%), and small shares of oil (2%) and bioenergy and waste (1.3%).

All of the incremental growth in power demand since 2000 has been met by renewables. The carbon intensity of power generation has been falling for decades. Electricity generation from coal decreased by 22% from 2010 to 2021, thanks to the rapid increase of generation from solar and wind, which was driven by a combination of subsidies and rapidly falling capital costs. The average annual growth rate of electricity generation from solar from 2010 to 2021 was 56%. It was 16% for wind. In fact, renewable energy penetration is more than demand. Today, around 30% of Australian households have solar PV on their roof, the highest penetration rate in the world.

Figure 7.1 Electricity generation by source in Australia, 2000-2021



Australia's electricity mainly comes from coal, with an increasing share of natural gas since 2008. Since 2000, all the power demand growth has been met by renewables.

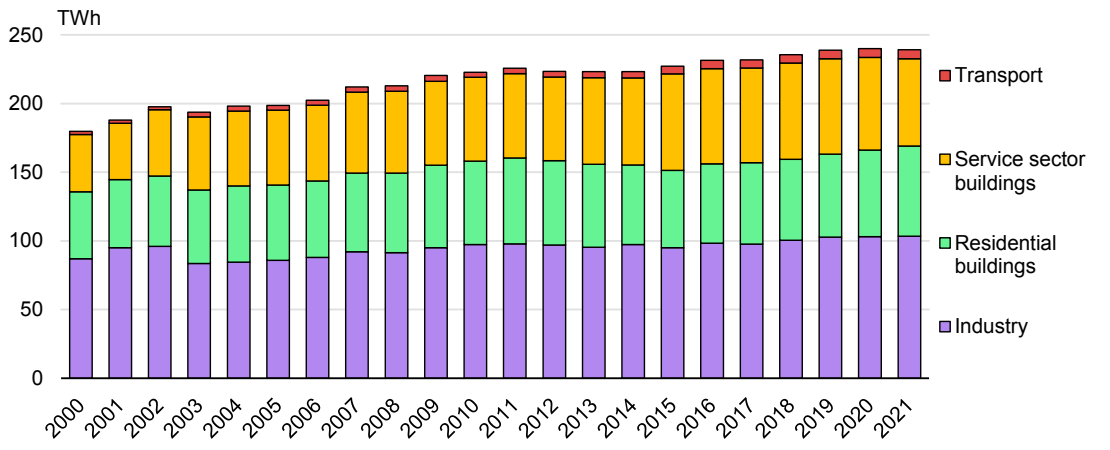
Note: TWh = terawatt hour.

Source: IEA, (2022a).

Electricity demand

Supported by strong economic growth, notably in the commercial buildings sector, Australia's electricity demand has increased by 6% in the past decade, reaching 239 TWh in 2021, compared to 223 TWh in 2010 (Figure 7.2). The industry sector consumed 103.4 TWh (43% of the total), followed by service sector buildings at 63.7 TWh (27%), residential buildings at 65.6 TWh (27%) and the transport sector at 6.5 TWh (3%).

Figure 7.2 Electricity final consumption by sector in Australia, 2000-2021



Electricity is the main source of energy for both the industry and buildings sectors.

Note: TWh = terawatt hour.

Source: IEA, (2022a).

In 2020, the Covid-19 pandemic led to only moderate reductions in electricity demand, with changes at the scale of yearly weather variations. The pandemic slightly influenced the

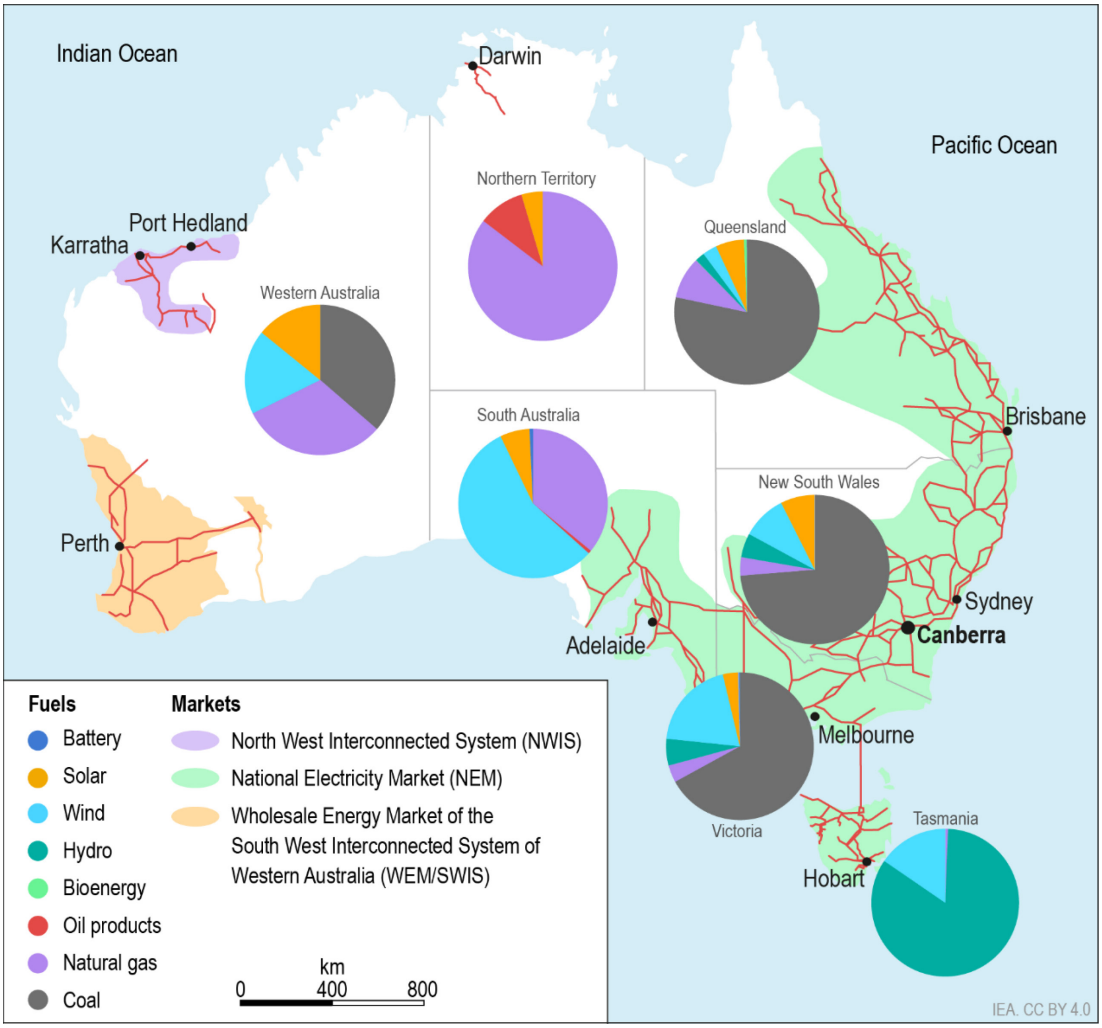
demand curve, however, with a significant decrease in the morning peak (between 6 am and 8 am), partially offset by slight increases in daytime demand and higher evening peak.

Self-consumption has moderated the increase in electricity demand from the grid. For example, in the NEM, total electricity consumption was 3% higher in 2020 than in 2014, but electricity demand from the grid decreased by 2% over the same period, with 13 TWh generated from rooftop solar in 2020.

Power systems in Australia

The NEM is the most extensive integrated power system and wholesale electricity market in Australia, incorporating five states and the Australian Capital Territory and covering all of the east coast through to South Australia. Western Australia has two separate systems: the South West Interconnected System (SWIS) and the North West Interconnected System. The AEMO operates the NEM and the Wholesale Electricity Market for the SWIS, which is not connected to the NEM and not a focus of this review.

Figure 7.3 Electricity generation mix and power systems in Australia



Source: IEA, (2022).

The National Electricity Market

The NEM is comprised of five regions: Queensland, New South Wales (includes the Australian Capital Territory), Victoria, South Australia and Tasmania. The NEM transmission system is long and weakly interconnected. Its topology reflects its genesis as a collection of state-based power systems serving local centres of generation and load. Six cross-border interconnectors link the five state-based transmission networks. Three of these are owned by state governments. The other three are privately owned. There are three DC interconnectors: Directlink (NSW-QLD Terranora), Murraylink (VIC-SA) and Basslink (TAS-VIC); and three AC interconnectors: Heywood (VIC-SA), Victoria to NSW Interconnector, and Queensland-NSW Interconnector (QNI).

Substantial interregional power flows occur between the NEM market regions. Queensland has surplus generation capacity, making it a net electricity exporter. Victoria was traditionally a net exporter of electricity thanks to low-priced lignite-fired generation, but significant coal plant retirements (Morwell in 2014, Anglesea in 2015 and Hazelwood in 2017) and outages contributed to the state becoming a net importer for the first time in 2019. New South Wales has relatively high fuel costs, typically making it a net importer of electricity. South Australia and Tasmania have a net import balance close to zero.

Electricity generation outlook and investment

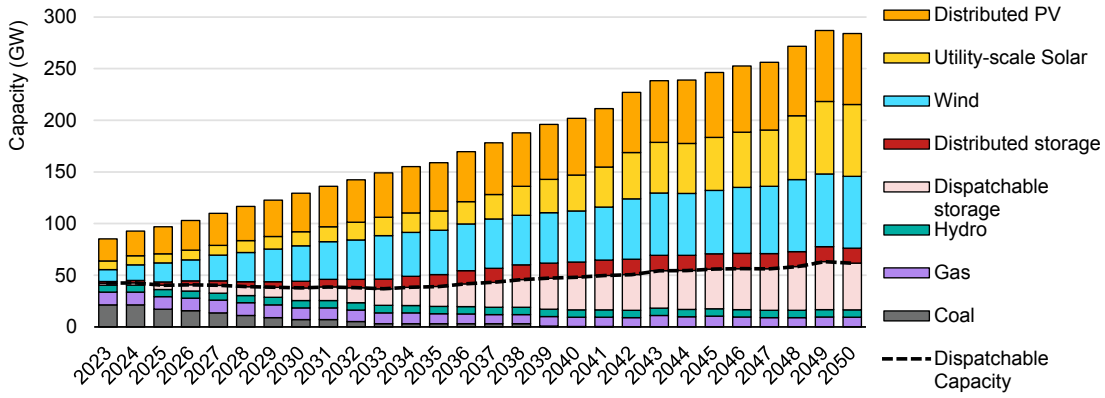
By the end of 2022, the installed generating capacity in the NEM reached 65 GW plus around 15 GW of solar rooftop PV. Peak demand in the NEM was 35 GW in 2020, the highest peak load since 2017. By April 2021, over 2.3 million customers had installed solar PV panels, or the equivalent of 30% of all households.

The AEMO's Step Change Scenario in the ISP 2022, the core energy transition pathway in line with the government's targets, models the NEM with renewables generating 83% of energy by 2030-31, 96% by 2040 and 98% by 2050[8].

In the Step Change Scenario, the NEM's total installed capacity is forecast to increase from 65 GW in 2022 to 173 GW by 2050 (not counting distributed storage and 69 GW of solar PV). It would be composed of a total of 141 GW of additional wind and solar. AEMO considers a need for investment in 63 GW of dispatchable capacity to firm the large amount of variable renewables. In total, 45 GW of new dispatchable storage capacity, 7 GW of existing dispatchable hydro and 9 GW of gas-fired generation by 2050 would be required to meet demand, according to the AEMO. Coal-fired generation would be withdrawn faster than today's announced retirements, with 14 GW of today's 23 GW, or 60% of current coal capacity, in the NEM retiring already by 2030.

[8] AEMO's step change scenario forecasts annual electricity consumption from the grid will double by 2050, as transport, heating, cooking and industrial processes are electrified and 60% of current coal generation exiting by 2030.

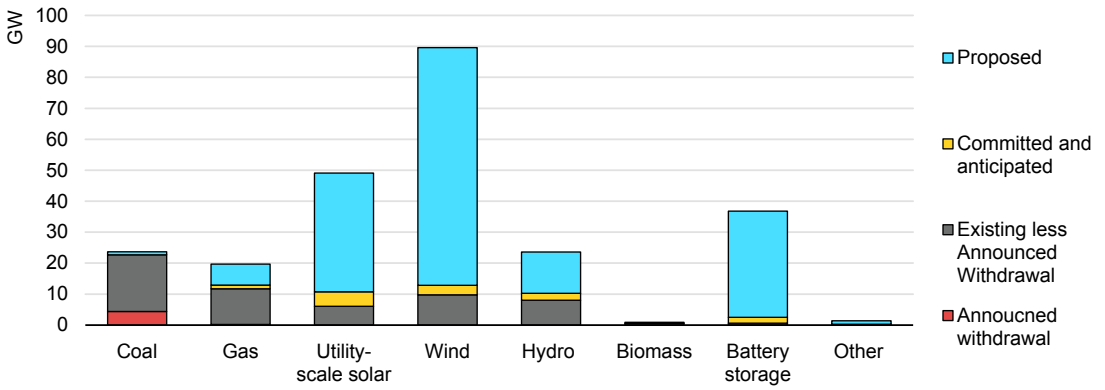
Figure 7.4 The Australian Energy Market Operator's electricity outlook: Step Change Scenario up to 2050



Note: GW = gigawatt; PV = photovoltaics.
Source: AEMO, (2022a).

Current investment trends already point to this energy system transformation being under way, with a major increase expected from wind power (see Figure 7.5 and Chapter 5) in the coming years. Investment in renewable energy and distributed energy sources has been strong and growing, even during the Covid-19 pandemic. In 2022, around 3 GW of large-scale solar and wind generation capacity entered the NEM, including Australia's largest solar farm, wind farm, and hybrid facility, with projects becoming larger and more complex than ever before. Up to 2030, major planned investment in the NEM will result in doubling the current installed capacity. The AEMO reports around 165 GW of proposed new capacity, of which 73.9 GW of wind, 38.7 GW of solar, 32.2 GW of storage, 11.3 GW of hydro, 6.6 GW of gas and 0.9 GW of coal.

Figure 7.5 Australia's existing and committed scheduled generation capacities in the National Electricity Market, 2022-2030



Source: AEMO, (2022b).

Based on closure dates reported to the AEMO, 19% of coal capacity is expected to close within the next eight years. However, the actual figure will likely be much higher as many coal generators have publicly announced coal generator closures earlier than what is currently reported to the AEMO (see Figure 7.4). By 2040, out of the total coal capacity of 23 GW, 10 plants, or 16 GW of capacity, are reaching their end of lifetime but are likely to

close up to a decade earlier in line with recent announcements (see Chapter 8). For example, in February 2022, Origin announced that the 2.88 GW Eraring Power Plant will close in 2025, seven years earlier than previously announced.

The energy industry is seeking to take advantage of the existing transmission and grid connection infrastructure and repurpose the sites of old/closed coal plants to install renewable energy, storage and other related infrastructure. The Australian Government has also set a target for the country's electricity sector to come up with 1 GW of new dispatchable energy to replace the production of the Liddell power station, which is due to retire in 2023.

Over the past decade, there have been few investments in new gas-fired power generation capacity. Barker Inlet (South Australia, 211 MW) was the NEM's first material addition of fossil fuel capacity since an upgrade to Eraring in 2012 alongside the Tallawarra B, which is currently under construction. The Barker Inlet gas plant was commissioned to replace the capacity lost by the retirement of Torrens Island A. The private sector only envisaged 316 MW of gas-fired power capacity at Tallawarra B in the Hunter Valley of New South Wales. The government stepped in with public investment in an additional gas-fired power plant, the Hunter Power project (Snowy Hydro Ltd), which will add 660 MW from two open-cycle gas turbines. This will be converted to a hydrogen burning generator in the future.

Institutional governance of the National Electricity Market

Energy ministers from the Australian Government and the six NEM state governments oversee the NEM through the Energy Ministers' Meeting framework. The EMM is tasked with overseeing the NEM legal foundations, the National Electricity Law and Rules.[9] Energy ministers work together through the EMM on priority issues of national significance and key reforms in the energy sector.

The NEM is operated and regulated by three institutional bodies: the AEMO, the AEMC and the AER. These institutions work collaboratively to support efficient investment in and operation of the Australian electricity system. The Energy Security Board (ESB) was established in 2017 and is the latest addition to the institutional framework. It focuses on energy security matters and has been driving market design discussions in Australia, working with the AEMC, the AER and the AEMO.

Electricity market and competition

The NEM continues to be characterised by market concentration. Around 30% of total generating capacity is owned by two companies, AGL and Origin Energy. Australia's electricity market has vertical integration of generation and retail ("gentailing"). Vertical integration provides benefits to energy retailers and generators by enabling them to manage price volatility in wholesale markets, with less need to hedge their positions in futures (derivatives) markets.

In 2020, the four largest vertically integrated participants in each region accounted for the majority of generation output and supplied more than half of the retail load (Figure 7.6). The NEM's three largest retailers – AGL Energy, Origin Energy and EnergyAustralia – supply 44% of the retail load, including 64% of small retail consumers. AGL Energy has

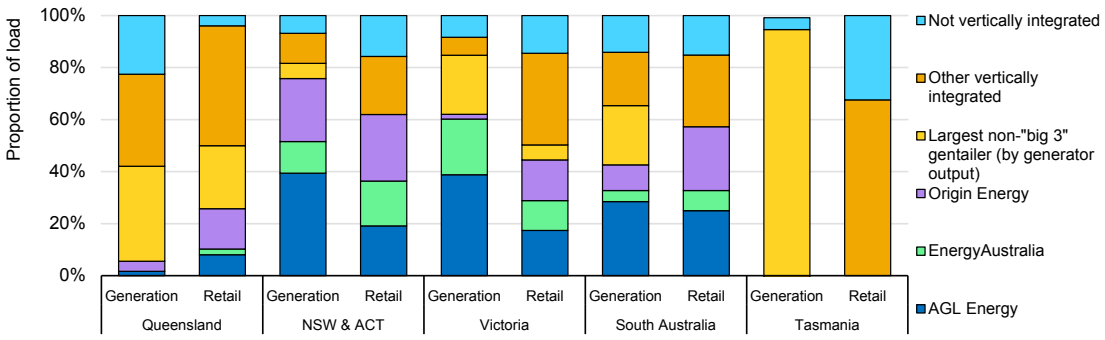
[9] The National Electricity Law is a schedule to the National Electricity (South Australia) Act 1996 which establishes the legal framework and key obligations governing the national electricity market and electricity network regulation.

the greatest market coverage with a significant presence in New South Wales, Victoria and South Australia. The remaining retailers also have links to generation activities, such as ENGIE (Simply Energy), Alinta Energy, Shell Energy (retailing as Shell Energy Australia and Powershop) and Pacific Hydro (Tango).

State-owned generators dominate in several states, notably Snowy Hydro (wholly owned by the Australian Government), Stanwell and CS Energy (in Queensland), and Hydro Tasmania (in Tasmania). At the same time, the retail market is also often served by publicly owned enterprises that dominate their respective regional markets, notably in regional Queensland, the Australian Capital Territory and Tasmania. This is the case of Snowy Hydro (retailing as Red Energy and Lumo Energy) and Hydro Tasmania (Momentum Energy).

Partly due to the gentailing structure, financial markets in the NEM have been characterised by a lack of deepness and liquidity for a range of years, as hedging is primarily done through vertical integration, as shown above. As a result, while the share of the "Big 3" has been in decline and new retailers have entered the market in the past five years, there is a risk for retailers without generation to survive in the NEM.

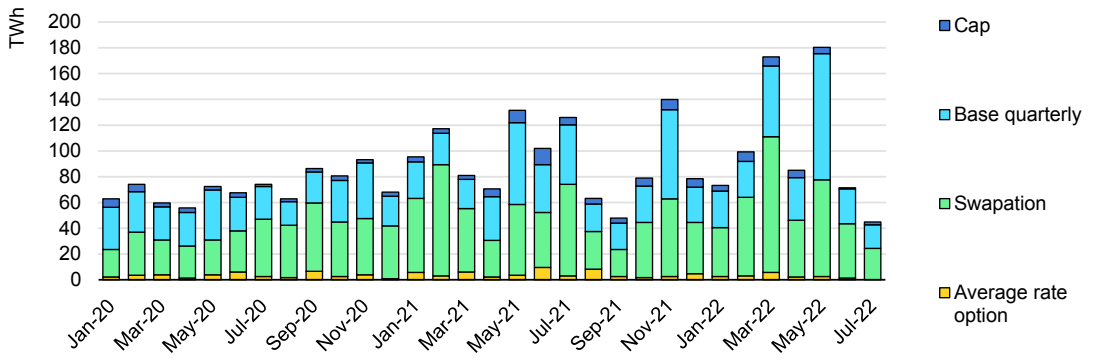
Figure 7.6 Vertical integration in the National Electricity Market, 2021



Notes: NSW & ACT = New South Wales and the Australian Capital Territory. The electricity generation market shares are based on generation output in 2021-2022. Retail market shares are based on market load in 2021-2022.
Source: AER, (2022a).

In its annual Health of the National Electricity Market report, the ESB raises the increased cost of financial hedges for retailers, notably those that do not have generation assets (ESB, 2022). With increasing and volatile spot prices, much above levels forecast in hedging contracts, the short-term cash-flow requirements rise for generators. This places pressure on retailers without generation assets. In June and July 2022, the liquidity in the contracts market ASX was below the historical averages.

Figure 7.7 Liquidity in the contracts market in Australia



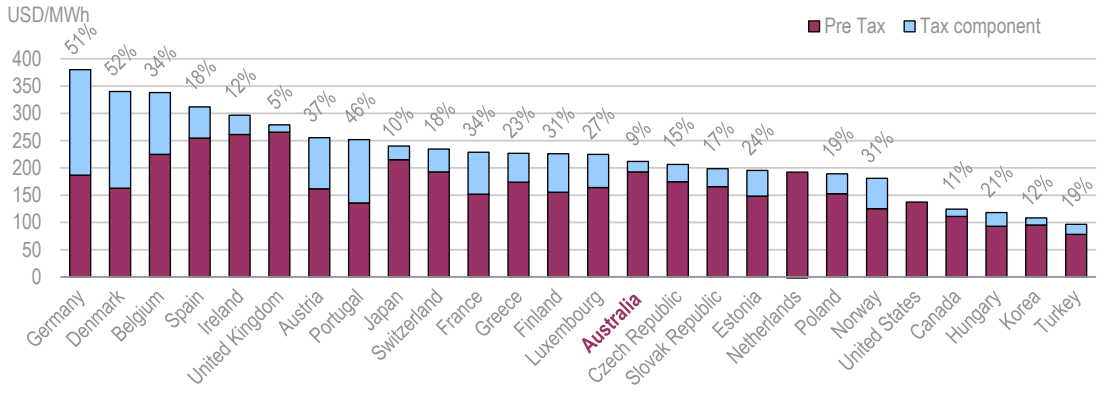
Note: TWh = terawatt hour.

Source: ESB, (2022).

Electricity prices

Australia's household electricity prices were 212 USD/MWh in 2021, including a 9% tax rate, slightly above the IEA average of 205 USD/MWh, with an average IEA tax rate of 24%. In 2021, the share of network charges was around 50% of the final retail price, while the wholesale price is only the second-largest component (AEMC, 2021a).

Figure 7.8 Household retail electricity prices in selected IEA countries, 2021



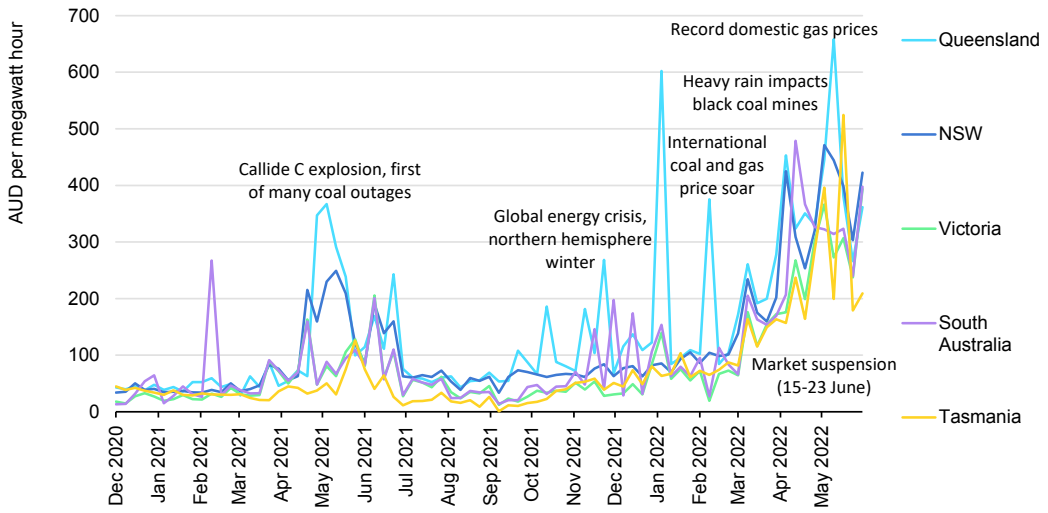
Household electricity prices are close to the IEA average with low taxes but high network cost

Notes: USD/MWh = US dollar per megawatt hour. Household electricity price data are unavailable for Italy, Mexico, New Zealand and Sweden.

Source: IEA, (2022b).

In January 2021, wholesale electricity prices across the NEM (on a volume-weighted average basis) were below 70 AUD/MWh in all regions. This reflects higher shares of VRE, more rooftop solar PV, lower contributions from coal and gas (and related fuel costs), and lower demand. However, in June 2022, wholesale prices (on a weighted weekly average) in the NEM reached more than 300 AUD/MWh. Weekly average prices in Queensland reached more than 650 AUD/MWh, as illustrated in Figure 7.9.

Figure 7.9 Weekly wholesale electricity prices in the National Electricity Market, December 2020- June 2022



Note: NSW = New South Wales.
Source: AER, (2022a).

Box 7.1 The National Electricity Market energy crisis of June 2022

Between 12 and 14 June 2022, sustained high wholesale electricity prices triggered an administered price cap of 300 AUD/MWh in Queensland, New South Wales, Victoria and South Australia. The price cap, combined with high fuel costs, contributed to several generators withdrawing capacity from the market.

The resulting supply shortfalls prompted the Australian Energy Market Operator (AEMO) to use its powers to direct generators to provide electricity. On 15 June, the AEMO took the extraordinary step of suspending the wholesale electricity markets to ensure a reliable supply of electricity. NEM operations were not designed to cope with a withdrawal of such large volumes of capacity and the AEMO was unable to sustain the level of manual resolution needed. During the market suspension, the AEMO determined that spot prices and participants were able to apply for compensation if those prices did not cover actual costs.

Following negotiations with generators and the resolution of plant outages, almost 4 000 MW of coal capacity returned to the market. Nevertheless, there were occasions when the market came close to actual supply shortfalls and the AEMO activated emergency reserves to reduce demand. On 22 June, the AEMO removed the price cap and on 23 June it lifted the market suspension.

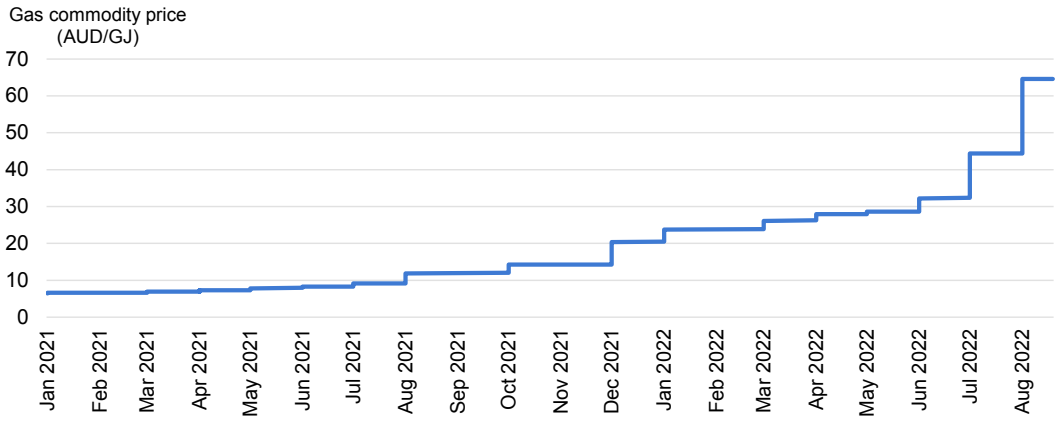
The Australian Energy Regulator (AER) is investigating whether bidding behaviour breached any rules and legislation. It will examine broadly if generator conduct and market outcomes were consistent with an efficient and competitive market serving the long-term

interest of consumers. The regulator released an assessment in the Wholesale Electricity Markets Performance report 2022 on 15 December 2022 and found that there may be evidence of may be evidence of sustained exercise of market power through offering capacity higher than cost with the intention to increase prices.

Source: AER (2022a, 2022b).

Price increases were largely driven by high international fuel costs and rising natural gas prices (see Figure 7.9), with the tripling of the LNG netback price[10] from the start of 2021 to June 2022 (Figure 7.10). In June 2022, considerable tightness in the eastern Australian gas market was caused by a confluence of factors: a period of abnormally low temperatures resulted in a substantial increase in power and heating gas demand and technical failures at several coal-fired plants exacerbated the spike in gas demand. These events occurred as global LNG export demand, and thus the call on Australian LNG, rose to record levels and global gas prices soared following Russia's invasion of Ukraine. As a result of sharply increasing wholesale prices and reports from market participants that supply was insufficient to meet demand in the east coast market, the AEMO intervened to enforce a temporary price cap of 40 AUD/GJ in the Sydney and Brisbane short-term trading markets as well in the Victorian gas market. The AEMO also triggered the Gas Supply Guarantee for the first time, facilitating additional gas flows to the east coast market (see also Chapter 9).

Figure 7.10 Expected 2023 short-term liquefied natural gas netback price at Wallumbilla

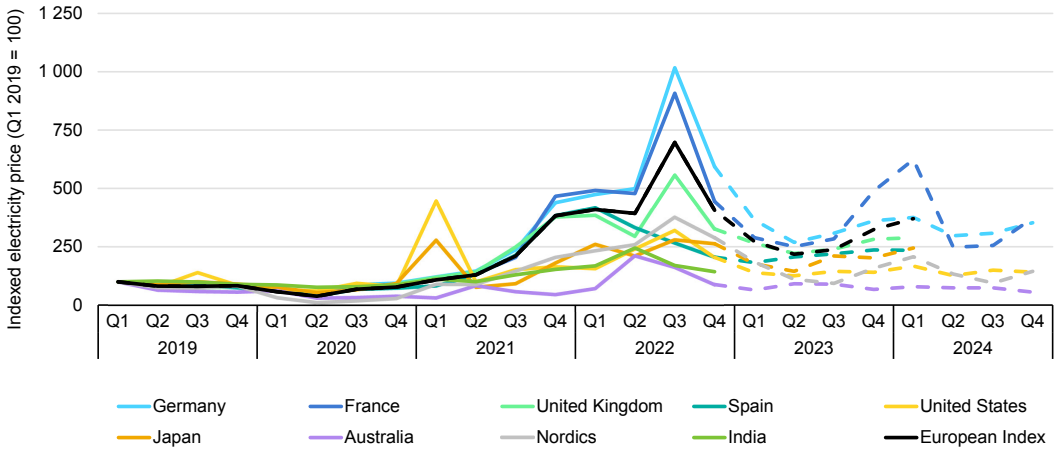


Notes: AUD/GJ = Australian dollar per gigajoule. Prices are for gas commodities only. Actual prices paid by users may also include transport and retail cost components. All offers are for quantities of at least 0.5 PJ per annum and a contract term of at least 12 months. Some offers in the chart may be between the same supplier and buyer and/or represent further offers between parties if a previous offer did not result in the execution of the Gas Supply Guarantee.

Source: ACCC, (2022).

[10] An LNG netback price is a measure of an export parity price that a gas supplier can expect to receive for exporting its gas. It is calculated by taking the price that could be received for LNG and subtracting or "netting back" the costs incurred by the supplier to convert the gas to LNG and ship it to the destination port. In Australia, the ACCC found that LNG netback prices based on Asian LNG spot prices and oil-linked LNG contract prices play an important role in influencing gas prices in the east coast gas market.

Figure 7.11 Electricity wholesale prices in selected countries, 2019-2024



Notes: The price index aggregates wholesale electricity prices across regions. It is calculated as the demand-weighted average of the current and previous three-quarter indexed prices. For example, prices for Australia and the United States are calculated as the demand-weighted average of the available prices of their regional markets. Continuous lines show historical data and dashed lines refer to futures. Price estimates for Q3 2022 and beyond are based on the forward baseload electricity prices, except for the United States, which are based on EIA 2022 data. The forecasted prices for Japan are volume-weighted estimates of the latest JPX settlement prices, considering the baseload contracts (areas B1 and B3).

Sources: IEA analysis using data from RTE (France), Red Eléctrica (Spain), Elexon (2022), AEMO (2022), EIA (2022), Nord Pool (2022), IEX (2021), EEX (2022), JPX (2022), ASX (2022). Latest update: 29 November 2022.

Box 7.2 Government measures to address rising energy prices and inflation

Australia is a major energy exporter and faces some very unique challenges linked to its large exports. Governments around the world have been dealing with the impacts of the global energy crisis and have focused on five areas more broadly:

1. smart demand reduction during peak hours
2. energy sector contributions to support vulnerable households and businesses (transfers and price controls)
3. liquidity support of utilities
4. escalating clean energy investment
5. decoupling the gas price impact on the wholesale electricity market.

The IEA has worked with the European Commission (EC) and launched the Playing my Part campaign, which provides actions for citizens to reduce their bills and aggregate energy demand. The European Union (EU) adopted regulations on saving gas (5%) and electricity (10%) during the winter of 2022-2023, with a focus on peak hours, relying on voluntary demand-side measures.

The United States' Inflation Reduction Act (IRA) supports clean energy investment, with USD 300 billion in deficit reduction and USD 369 billion in energy security and climate change programmes over the next ten years, notably through tax credits and policy measures. In 2022, European governments committed around USD 500 billion (Sgaravatti, Tagliapietra and Zachmann, 2022) in relief payments for high energy bills

through income transfers and energy price controls (price caps at wholesale and/or retail levels, limiting margins, lowering taxes, etc.). Germany presented a EUR 200 billion relief plan to finance energy price caps and energy subsidies to ease the impacts of high energy prices for industry and citizens. The United Kingdom approved an energy price guarantee as a temporary measure in place until end of March 2023 (an extension is sought for another three months). As a result, the average household energy bill would not exceed GBP 2 500 per year.

The EC is working on measures to solve the issue of decreased liquidity for energy retailers due to high energy costs, requiring increasingly high amounts of collateral for gas and power trading. European Unioncountries adopted a broad range of short-term electricity market interventions. To guide those interventions, the EC presented a toolbox in October 2021 for member states to mitigate the impact of high energy prices on consumers' bills. In October 2022, the European Union adopted Council Regulation 2022/1854, which includes for the whole European Union a 180 EUR/MWh cap on the revenues of electricity producers facing low production costs (so-called infra-marginal technologies such as renewables and nuclear). The revenues from this implicit "windfall tax" can be used to reduce households' and businesses' electricity bills.

Price caps were adopted in Portugal and Spain ("Iberian exception"), allowing the temporary decoupling of the price of gas from power by setting a maximum gas price of about 50 EUR/MWh. Governments provide a subsidy payment to gas generators, compensating for the difference in the market price of gas and the wholesale price cap. This lower gas price is passed on to the electricity wholesale market, as gas remains the marginal price setter.

The EC is accelerating work on the structural reform of the EU electricity market design. For March 2023, it intends to examine options for short-term reforms focused on the lessons learnt from the current crisis along four key areas:

- investment signals in power sector decarbonisation: public finance (contracts for difference), private finance (power purchase agreements)
- introduction of a permanent shock absorption mechanism: continuation of the revenue cap on infra-marginal technologies (possible in case of sustained high-fuel prices)
- improving short-term and balancing markets by lifting barriers to flexibility and grid constraints (network code for flexibility, storage, demand response)
- retail and consumer-focused policies, improved liquidity for retailers amid high price volatility.

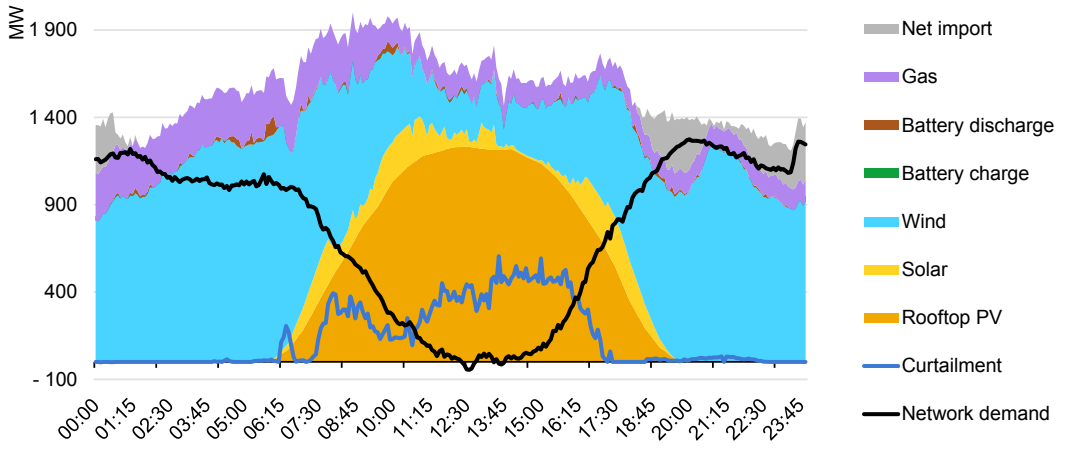
Sources: IEA, (2022c); EC, (2022); Sgaravatti, Tagliapietra and Zachmann, (2022).

Managing annual and seasonal variability of variable renewables

In 2020, renewable generation including rooftop solar PV accounted for almost 20% of total power generation in the NEM. That same year, wind output exceeded gas generation for the first time in the NEM and is often curtailed. For instance, on 21 November 2021 in

South Australia, rooftop solar covered all demand, the actual electricity demand on thenetwork reached negative values around midday, which led to a large curtailment of wind generation.

Figure 7.12 South Australia electricity balance, 21 November 2021



As rooftop solar covered all demand, the actual electricity demand on the network reached negative values around midday. A large share of wind generation was curtailed as a result.

Note: MW = megawatt; PV = photovoltaics.
Source: GPE, (2022).

Growth in rooftop solar PV is shifting the daily peak later in the day to the early evening when solar output is low or unavailable and business and residential use overlaps. On the other hand, the grid is starting to experience periods with very low demand in the middle of the day, posing challenges to the market operator in balancing supply and demand and maintaining the system in a secure operating state.

Most of Australia's jurisdictions now have a summer peak, driven by a very high demand for space cooling. Seasonal reliability issues have begun to emerge during "shoulder" and "winter" periods in addition to the summer peak, which has been increasing in recent years. The NEM system operator, the AEMO, is under pressure to adapt its system operation practices and seasonal power system security settings.

Some NEM regions are experiencing very high levels of intra-day renewable penetration. In recent years, for several periods South Australia operated a power system where distributed and grid-scale solar PV generation exceeded total regional demand. By 2025, other mainland NEM jurisdictions could be regularly operating for periods of the day with close to or above 50% renewable penetration. As in many markets around the world, Australia now also sees negative prices emerge in the wholesale electricity market during such periods. Future power system operation will experience these situations on a regular basis.

According to the AEMO's 2022 ISP, in 2030, 50-52% of total generation will come from grid-scale VRE and about 18% from distributed VRE. The AEMO forecasts that in five years, 313% 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 NEM has seen a few significant reforms in recent years that form the starting point for a future-proof market design with increasing flexibility needs.

Short-term trading in the National Electricity Market

Following the AEMC's rule change in October 2021, the five-minute settlement started, which allows for changes to metering, settlement and bidding processes in electricity retail and wholesale market systems. This provides an economic incentive for flexibility, thus supporting the system integration of VRE, notably the participation of demand response (DR) and storage. The five-minute settlement provides the foundation for genuine participation of renewables, batteries and DR in the wholesale spot/dispatch market. This trend is going to increase in the coming years as thermal dispatchable capacity will retire. Over the past two years there were six new participants in virtual power plants, battery or demand response technologies (AER, 2022b). Battery and demand response together surpassed the shares of coal and gas generators in a range of ancillary services.

Demand response

Traditionally, the NEM did not have a formal DR market. Instead, DR participated in the reserve schemes. DR can be activated under the AEMO's Reliability and Emergency Reserve Trader (RERT), the temporary Interim Reliability Reserve and potentially under the jurisdictional strategic reserve adopted by the National Cabinet in October 2021. In addition, some DR was enabled through the direct load control (ripple-control function) for hot water systems.

Since October 2021, the NEM has incorporated a formal wholesale DR mechanism, following a new rule adopted by the AEMC. Participants are paid the wholesale spot price for dispatched DR. In 2022, up to 66 MW of instantaneous response was registered across four regions of the NEM. Utilisation of the wholesale demand response mechanism has been limited since it began in October 2021. Only one participant, Enel X, has registered for participation in the wholesale demand response mechanism. A maximum of 30 MW instantaneous contribution was activated in New South Wales and up to around 15 MW in Victoria from May to June 2022.

Energy storage

Batteries are now making an important contribution to frequency control ancillary services (FCAS). In 2021, four batteries (totalling over 500 MW) entered the NEM. This brought the total number of batteries in the NEM to nine (totalling over 800 MW). This included the Victorian Big Battery (360 MW), now the largest battery in the NEM according to the AER's *State of the Energy Market 2022 (*AER, 2022a). An additional 1 700 MW of battery capacity is committed to enter the NEM by 2025. ARENA and the CEFC are also investing in grid reliability projects. It is anticipated that pumped hydro storage will play an essential role in the NEM, mainly the Snowy Hydro scheme in New South Wales, which is being expanded by 2 GW (Snowy 2.0 project) to reach a total of 6 GW in 2026. One new pumped storage hydro investment project has been announced in the former Kidston Gold Mine in North Queensland, supported by ARENA.

Smart meters

By July 2021, the NEM had deployed over 5 million smart meters, covering 38% of small consumers. Victoria mandated the roll-out of smart meters and hosts most of the meters deployed in the NEM. In 2017, the AEMC rules introduced competition in metering services which require all meters to be advanced or smart meters. Experience shows that this policy has not led to a major push in the roll-out of smart meters. In 2021, the AEMC opened a review of the metering competition (AEMC, 2021b) and is consulting with all stakeholders on ways to fast-track the roll-out of smart meters across the NEM regions. In 2022, the AEMC adopted a goal of reaching 100% smart meter penetration by 2030.

Electricity networks and grid development

AEMO's ISP recommends AUD 12.7 billion of "actionable" transmission projects to develop, operate and maintain generation, storage and network investments of the NEM to 2050, with six priority projects across the NEM:

- upgrade of Victoria-NSW interconnector (VNI minor)
- REZ zone NSW (Central-West Orana REZ transmission link)
- new HVAC interconnector NSW-SA (Project EnergyConnect)
- network reinforcement (HumeLink) in southern New South Wales
- new interconnection VIC-NSW (VNI West)
- new subsea interconnector TAS-mainland Australia and related TAS transmission network upgrades (Marinus Link, Hazelwood-Heybridge).

These projects also require upgrades to transmission capacity between New South Wales and Queensland, reinforcements in the greater Sydney area transmission grid, expansions in New South Wales, and network reinforcements in Queensland.

Box 7.3 Challenges and opportunities for the integration of very high shares of variable renewables in Australia

Power system stability and strength: With the closure of very large coal-fired power plants in the National Electricity Market (NEM), the power system needs to deal with the lack of inertia and network support and control ancillary services products, once provided by these conventional generators. Given the "stringy" nature of the NEM and the physics of network support and control ancillary services, voltage control diminishes rapidly over distance requiring regular points of "injection" along transmission paths. This is a significant issue, given the nature of the NEM. Since the start of the NEM, frequency control ancillary services (FCAS) were co-optimised through the dispatch. However, the cost for the Australian Energy Market Operator's (AEMO) directions to stabilise the system have increased as the NEM power system transforms.

System adequacy: This is the ability of a power system to cope with a given load at all times. It can be ensured even in a system mainly based on variable renewables as long as substantial sources of flexibility are available, including demand response, large-scale storage, peak generation units, and well-developed transmission networks and interconnections. The maturity, availability and cost of different flexibility mixes need to be further evaluated by AEMO's Integrated System Plan.

Operational reserves: The sizing of these reserves and the regulatory framework for balancing responsibilities and procurement has been adapted in the NEM following the South Australia blackout and the NEM 2022 energy market crisis. The government adopted multiple-ride through requirements for renewables. Forecasting methods for variable renewables would need to be continually improved. Enhancements to the AEMO's procedures are necessary to increase the transparency of generator availability, improving the range of information available to the AEMO on generator availability in the medium term. As the AEMO is the system and market operator of the NEM, it can enhance how reserves are managed, notably for natural gas and its dispatch co-ordinated with electricity. Further assessment of the impacts of distributed photovoltaics (PV) on the power distribution network and their implications for electricity security is needed. The government needs to work with the AEMO to conduct a study on system operation with very high solar PV shares. This should also include demand-side management and response mechanisms.

Grid development: Substantial efforts are necessary at both transmission and distribution levels to adapt the power system to more small-scale technologies and decentralised power generation as well as sector coupling, such as solar PV, electric vehicles, and battery storage or smart grids. This requires proactive steps and public engagement in long-term planning to assess costs and work with citizens on social acceptance of new infrastructure. These efforts can nonetheless be partially integrated into the renewal of ageing network assets, which are still largely in place today. Substantial investment is needed to render the transmission and distribution grids resilient against the impacts of climate change and extreme weather events. This includes not only new design standards but also reinforcements along the grids.

Key market reforms for the National Electricity Market

In August 2022, energy ministers agreed to the National Energy Transformation Partnership. The partnership is structured around six priorities that are considered critical to the successful transformation of Australia's energy system:

- accelerate nationally significant transmission projects
- plan for generation and storage adequacy
- understand demand evolution
- co-ordinate gas and electricity planning
- address enabler requirements
- enhance energy security management.

Against these priority themes, Australian governments will deliver a series of interconnected work streams, with early actions already underway including steps to:

- introduce an emissions reduction objective into the national energy objectives
- co-design a First Nations Clean Energy Strategy with First Nations people to help drive the energy transformation in the community
- identify and declare transmission of national significance to progress the timely delivery of critical projects and ensure better community consultation
- co-operate on plans for generation and storage adequacy, power demand, workforce, supply chain, and community needs
- collaborate on energy security management, including cybersecurity and fuel availability.

Additional work streams will be added over time to reflect the changing nature and scope of the energy transformation and address any emerging challenges and opportunities.

Post-2025 market reforms

Building on the 2017 Finkel Review, the ESB prepared a package of post-2025 market reforms for the NEM. The National Cabinet endorsed the reform recommendations in October 2021 (ESB, 2021). The ESB provided advice across four broad work streams: 1) resource adequacy mechanisms; 2) transmission and access reform pathways; 3) essential system services and scheduling ahead mechanism; 4) effective integration of distributed energy resources and flexible demand.

Australian governments and the ESB are progressing implementation of the detailed reform package, including further work on some key elements, including transmission access reform and work on a framework that delivers adequate capacity, ensures an orderly transition and incentivises new investment in firm renewable energy to ensure the system can meet peak demand at all times. Progress was made through a range of reforms and consultations:

- On 29 October 2021, a summary of rule changes complete and underway for essential system services and scheduling and ahead mechanisms.
- On 17 December 2021, its Delivering the Distributed Energy Resources Implementation Plan – Horizon One, identifying key issues to be addressed, reform activities and details about how stakeholders can engage. More recently, it established its Customer Insights Collaboration, which looks at barriers and enablers to customer reward for distributed energy resources and flexible energy use.
- On 10 May 2022, its Transmission access reform – Consultation paper, in which the ESB shortlisted four out of ten models to meet its transmission access objectives.
- On 20 June 2022, its Capacity Mechanism High-level Design Paper, which describes the ESB's preferred capacity mechanism to establish long-term resource adequacy.

Resource adequacy mechanisms

In December 2018, Australian energy ministers agreed to implement a Retailer Reliability Obligation that commenced in July 2019. In 2022, the ESB recommended the introduction of a lever for energy ministers to make an instrument for the existing **Retailer Reliability Obligation**, requiring electricity retailers or large energy users to enter into sufficient

contracts for dispatchable capacity (including DR). This would extend the RRO which exists in South Australia to all NEM regions.

In March 2020, upon a proposal by the ESB, energy ministers agreed to **implement two interim reliability measures** (EMM, 2020) consisting of: 1) an out-of-market capacity reserve, triggered to keep unserved energy (USE) to no more than 0.0006% in any region, in any year; and 2) amending the triggering arrangements for the Retailer Reliability Obligation to be based on a forecast breach of 0.0006% USE (rather than the existing reliability standard of 0.002% USE) to improve incentives on retailers to contract and support reliability. The interim reliability measure is in operation until 31 March 2025. The interim reliability measure for generation and interregional transmission elements in the NEM is a maximum expected unserved energy in a region of 0.0006% of the total energy demand in that region for a given financial year. The measures will be reviewed by July 2023.

The ESB recommended designing a **capacity mechanism** to provide a signal for new investment in dispatchable capacity to ensure reliability is maintained as the share of variable renewables grows. The ESB's rationale is based on the view that fast replacement of capacity needs to be built before coal-fired power stations close (Eraring 2025-26). In June 2022, the ESB released the capacity mechanism paper following stakeholder consultation of its proposed high-level design for the NEM and reported to energy ministers.

In December 2022, energy ministers endorsed a new **Commonwealth Capacity Investment Scheme** to underwrite investment in zero emissions dispatchable power capacity and storage technologies. Eligible projects will include those eligible under existing state-based schemes and on-grid, public and private utility-scale projects that reached FID after 8 December 2022. A tender process will be launched to support the optimal mix of generation and storage for reliability with different configurations (co-located and stand-alone). Structured as contracts for difference, an agreed revenue 'floor' will cover project operating costs and debt payments and the government will pay the difference when revenues fall short of the ceiling (market price). A share of profits is clawed back, when revenues exceed an agreed ceiling.

Transmission and access reforms

The AEMO's ISP supports the development of detailed, co-ordinated plans for **renewable energy zones**, where the grid would be developed to accommodate increasing renewable electricity generation. The National Cabinet agreed in October 2021 to adopt the REZ planning rules and the principles for an interim REZ framework to address the network planning implications for REZs.

The ESB has developed proposals for **transmission access reforms** and a **Congestion Management Model**, adapted for integration with REZs. The goal is to improve investment certainty, manage access risk, boost operational efficiency and incentivise technologies that alleviate congestion. Four models were proposed in a consultation paper:

- Congestion zones with connection fees: Investors receive clear upfront signals about which network locations have available hosting capacity.
- The Congestion Management Model with universal rebates, which establishes a single, combined-bid energy and congestion market.

- Transmission queue: Investors that connect in uncongested locations receive priority rights.
- Congestion relief market: Changes to the market and settlements to provide separate revenue streams for energy and congestion relief.

Essential system services and scheduling ahead mechanisms

The ESB identified priority work to be done to value and procure essential system services as the mix of electricity generation evolves in the NEM. The AEMC is implementing a large part of this work and rule change proposals on frequency control, operational reserve services, scheduling and procurement mechanisms, and system strength frameworks, which are at various stages of development. The following important rule changes have been developed or implemented:

- fast frequency response market ancillary service – completed on 15 July 2021
- primary frequency response incentives – completed on 8 September 2022
- operating reserve market – draft determination expected on 30 June 2023
- efficient management of system strength – completed on 21 October 2021
- investigation into system strength frameworks – completed on 15 October 2020
- synchronous services markets – draft determination expected on 17 September 2022
- introduction of ramping services – draft determination expected on 30 June 2023
- capacity commitment mechanism for security and reliability services – draft determination scheduled for 30 June 2022.

In 2021, the AEMC rules introduced two new market ancillary services that will enable flexibility from new technologies to provide FCAS services. The approach has been to create markets for very specific services to open the markets up for new technologies and competition, where possible. However, this may fragment the market for new essential system services into very small markets, which may hamper the emergence of new technologies and promote anti-competitive behaviour. On the positive side, the AEMC rules have activated the participation of battery storage and DR aggregators, which now provide FCAS across all NEM regions alongside virtual power plants (AER, 2022b). However, renewable energy generators, often the cause of disturbances, have not been providers of FCAS. From October 2023, two very fast FCAS services will be introduced.

Effective integration of distributed energy resources and flexible demand

The National Cabinet supported the Distributed Energy Resources Implementation Plan, providing new ways to trade and other technical and process reforms, enabling consumers to try different products and switch providers. However, the NEM has yet to advance on the flexibilisation of demand through times-of-use pricing and peak shaving products (DR for industry) and consumer campaigns to save electricity consumption during peak hours.

Electricity security

Maintaining system security has been an emerging concern for several years. The NEM has seen a fast retirement of conventional power plants, and NEM participants do not have

visibility for reform plans on how to replace ancillary services, adapt the market design aspects and improve the resilience of the infrastructure exposed to climate change risks.

Following the South Australia blackout of 2016 and the June 2022 market crisis, electricity security has become a priority issue for the NEM and its market bodies.

The AEMO has significantly stepped up work and invested in its short-, medium- and long-term assessments of the network and generation adequacy and reliability supervision. It publishes the National Electricity Forecast Report, which includes annual energy and maximum demand forecasts for the next ten years by NEM region; the Electricity Statement of Opportunities, an assessment of supply adequacy in the NEM for the next ten years which highlights opportunities for generation and demand-side investment; and the NEM constraint reports, which provide details on interconnector capacity and constraints in the transmission network. Generators also need to inform the AEMO of their closure no less than three years ahead of time and work with the AEMO to help minimise the associated reliability and power system stabilisation risks in the lead up to the closure. The Electricity Statement of Opportunities finds that reliability continues to deteriorate during the peak summer period. The AEMO forecasts deteriorating reliability in 2026-2027 up to 2030-2021 in New South Wales and Victoria.

The AEMC's Reliability Panel sets reliability rules in line with the National Electricity Rules. The AEMC's Reliability Panel evaluates the security of supply based on the volume of electricity not supplied or USE across the NEM. The standard expresses the maximum expected amount of energy demand (out of total demand) that can be unmet in each NEM region in a year. It is used to set the administered market price cap. The NEM reliability standard is defined as 0.002% USE. Since 2009, USE events have only occurred in three years – 2009, 2017 and 2019. In 2018-2019, USE amounted to 0.0021%. There was no USE in 2020 or 2021. The AER regularly evaluates the system's average frequency and duration of interruptions and system lost load at the distribution level.

In 2022, the AEMC's panel completed its quadrennial Reliability Standard and Settings Review, in accordance with the National Electricity Rules, to enter into force from 1 July 2024 to 30 June 2028. The NEM's reliability settings include the: 1) reliability standard; 2) market price cap; 3) cumulative price threshold; 4) administered price cap (APC); and 5) market price floor.

The NEM reliability standard recognises that 100% power system reliability would be too expensive. The market price cap applies all the time as a maximum spot price approximating the value the marginal consumer would put on a MWh of USE (i.e., the "value" of lost load). It is set at an administrative limit to allow peaking generators to receive sufficient scarcity rents to make them financeable and be available to meet the reliability standard. The APC was intended to limit the exercise of market power by limiting sustained periods of high market prices but was not reflective of periods of very high fuel costs. The APC has only been used three times in the 24 years since the NEM commenced, most recently in 2022 (see Box 7.1).

Following an extended period of unprecedented volatility and extreme prices which forced the suspension of the wholesale electricity market in June 2022, the AEMC published a rule change to temporarily increase the APC from 300 AUD/MWh to 600 AUD/MWh. The increased APC will be in place from 1 December 2022 to 1 July 2025. Amid NEM's energy system transformation, the NEM could be continuously challenged with the APC setting and may require structural reforms.

Electricity emergency policy and response

Ensuring the security of the power system and managing the response to electricity supply emergencies is the responsibility of the AEMO as decreed by the National Electricity Law and detailed in the National Electricity Rules. All jurisdictions within the NEM (Queensland, New South Wales, the Australian Capital Territory, Victoria, Tasmania and South Australia) have adopted the National Electricity Law.[11]

All jurisdictional participants in the NEM have signed a memorandum of understanding with the AEMO on the use of emergency powers. These memoranda of understanding provide guidance on jurisdictions' use of emergency response legislation as well as their management of emergency responses. The guidance is based on the Power System Emergency Management Plan. The AEMO does not, however, have the legal power to intervene at a distribution level.

Responses to emergencies in the NEM vary depending on the severity of the supply disruption. Incidents are categorised on a scale from one to five, with level one representing a minor incident and level five indicating that a jurisdiction has enacted its emergency powers.

Since 2005, the NEM has seen five instances of load shedding to maintain reliability – twice in Victoria and three times in South Australia. However, emergency reserves have recently been increasingly required to maintain reliability, with the RERT deployed 15 times in the last five years but never before that.

AEMO has to intervene more frequently in the system through so-called directions in the dispatch, which should be a last-resort intervention if the market fails to deliver.[12] Most of the interventions were in South Australia, reflecting the increasing needs to manage inadequate system strength in South Australia (which found itself in an island state frequently over the past years) but also to manage NEM system reliability. The cost of these directions is significant, with the ESB reporting that it amounted to AUD 14.45 million in South Australia during Q2 and Q3 2018. In 2021, total costs for directing South Australian generators for system strength reached AUD 94 million – almost double those in 2020 (AER, 2022a).

AEMO dispatches services in eight FCAS markets to maintain system frequency at close to 50 Hz, including services to raise and lower regulation services, raise and lower 6-second contingency, raise and lower 60-second contingency and raise and lower 5-minute contingency. Raise contingency costs are recovered from generators, lower contingency costs are recovered from market customers. All costs are paid by the retail consumers in the end.

[11] Power system emergencies in other electricity markets (Western Australia and the Northern Territory) are managed through jurisdiction-specific arrangements.

[12] Under the National Electricity Rules, the AEMO is allowed to intervene in the operation of the energy and ancillary services markets in circumstances where it believes the market response has been inadequate to maintain a reliable and secure power system, or in response to unexpected events. The AEMO can issue directions to registered market participants (typically generators) to take action to maintain or re-establish the power system to a secure, satisfactory or reliable operating state. A registered market participant must use its reasonable endeavours to comply with the AEMO's directions unless doing so would be a hazard to public safety, materially risk damaging equipment or contravene another law. The AEMO's directions result in compensation payments.

Costs of services for maintaining frequency (frequency control ancillary services, FCAS, including for regulation and contingency purposes) are fluctuating but their total volume has increased for several years. Historically, FCAS costs were comparatively low in relation to energy costs. However, these costs have risen steadily over the past few years for the local levels.

FCAS costs averaged around AUD 735 000 per week between 2009 and 2015 (less than 0.5% of total NEM energy costs) but have jumped nearly fivefold to an average of over AUD 3.5 million per week between 2016 and 2018 (representing up to 2% of total NEM energy costs) and reached a record high of AUD 438 million over the year 2021 (AER, 2022a). Of the AUD 438 million, AUD 282 million, or 64%, came from Queensland. This relates to the impact of transmission upgrade works involving scheduled outages of the interconnector, which regularly led to very high prices and costs for local contingency FCAS products in Queensland in 2021. FCAS costs have since come down in the first three quarters of 2022 to a total of AUD 181 million.

Reserve production

The RERT is a function conferred on the AEMO that allows it to procure out-of-market reserves. The AEMO maintains a panel of RERT providers that it can call on to provide RERT services.

Interruptible contracts

The NEM has bilateral contracts between the AEMO and some major loads in each NEM region, enabling the AEMO to quickly reduce regional consumption for relatively short periods. These interruptible load contracts operate like call options but do not impose strict outage-like scenarios on customers. Over the years, the pool of programmes or contracts has expanded where customers may enter into agreements and accept interruptions to their loads in return for financial rewards.

Fuel switching

In the NEM, many gas generators are dual-fuel with oil/diesel. However, there are no obligations to hold alternative fuel stockpiles, with the availability of fuel reserves being mainly treated as a matter of commercial risk management. However, emergency intervention powers of state and Commonwealth ministers may provide an ability to ration and direct liquid fuel stocks to particular uses, such as electricity generation, should that be required in extreme situations.

Load shedding

During low reserve conditions, the AEMO can seek to instigate rolling blackouts, which would be implemented by the transmission and distribution companies. Each state government would make a load-shedding order based on their individual emergency response plans.

Assessment

Australia's NEM is undergoing a period of profound transformation, supporting rising shares of distributed renewable energy, notably solar PV, grid-scale batteries and electric vehicles. This is largely being driven by policies, supported by rapidly decreasing technology costs, and new consumer and business preferences.

Since the IEA's last in-depth review of Australia in 2018, the Australian Government and NEM market bodies have advanced and acted upon most of the review's recommendations to support electricity security and the system integration of rising shares of variable renewables. These were part of the 2017 Finkel Review, which provided for an Independent Review into the Future Security of the NEM – Blueprint for the Future.

Major reforms included the introduction of an integrated system plan with renewable energy zones and transmission priority projects as part of the AEMO's long-term planning. In addition, the NEM market design has seen important adjustments to short-term trading and the integration of higher shares of variable wind and utility-scale solar PV, thanks to the introduction of the five-minute settlement and a formal demand response at the wholesale level.

Building upon states' and territories' ambitions to accelerate the transition towards net zero, in 2022, the Australian Government legislated a net zero emissions goal for 2050 with an increased reduction goal of -43% by 2030 from 2005 levels under the Climate Change Act. The Australian Government also announced its goal to reach an 82% share of renewables in the NEM by 2030 and to introduce an emissions objective in the NEM, which will guide all NEM market bodies and actors. The new ambitions are reflected in the planning of the system operation. In June 2022, the AEMO published the latest edition of the ISP, which under the Step Change Scenario envisages an 83% share of renewables by 2030-31 and the retirement of all existing coal-fired generation by 2042, if not earlier.

States have constitutional power on electricity and gas prices and with regard to the generation mix. Co-ordination and co-operation are therefore essential. The National Energy Transformation Partnership, agreed by the EMM in August 2022 and progressed under the Energy and Climate Change Council, will focus not only on the pathway and reforms to achieve net zero across the energy sector, but also address emerging challenges in relation to electricity security, reliability and adequacy and climate resilience.

The global energy crisis also impacted Australia's energy markets in 2022, reflected in very high coal and gas prices for a sustained period of time. NEM trading was suspended on 15 June 2022 to avoid rolling blackouts and load shedding, and wholesale price caps were introduced for a short period. The reliability mechanism (the administrative price cap) had not catered to such a fuel supply crisis with sustained high fossil fuel prices.

In late 2022, the Commonwealth Treasury warned of rising inflation in Australia driven by energy price rises (a 56% increase in electricity and a 44% increase in gas prices). In particular, household electricity prices have been rising sharply in Australia over the last few months. For example, New South Wales saw a 22% rise in household electricity bills between June and September 2022.

Short-term crisis response

In the short term, energy efficiency and demand-side actions to save gas and electricity are very effective to deal with peak demand and mitigate the increases in power/gas bills (see also Chapter 4).

First, the government needs to accelerate all efforts by the NEM bodies to support smart energy savings and targeted consumer/business support to the most vulnerable while expediting the work on the structural NEM reforms.

Second, the government needs to adopt measures to improve hedges and the liquidity of smaller and medium-sized retailers, which are under increasing pressure to hedge the price hikes in the NEM.

Third, the Australian Government should focus on the improved liquidity of the east coast gas market and availability of natural gas with strong price markets to underpin the power market reliability and electricity security. The emphasis should be on the temporary nature of the regulation of domestic gas prices for more affordable electricity services.

In December 2022, the Australian Government proposed legislation for a mandatory code of conduct for wholesale gas market participants that includes a pricing framework as a basis for producers and buyers to negotiate domestic wholesale gas contracts at "reasonable prices", which should reflect the cost of domestic gas production, including a reasonable return, as calculated by the ACCC. A temporary emergency price cap on domestic gas prices at AUD 12 per gigajoule was introduced for a one-year period.

Progressing fast to the net zero power market design

In the medium term up to 2030, the NEM electricity system will undergo a profound transformation with the closure of conventional power plants and the emergence of diverse sources of generation, demand response, storage and distributed energy resources. Policy makers need to ensure that the NEM's energy-only market design remains "fit for purpose" and can continue to effectively deal with emerging operational and long-term market development challenges raised by the power system transformation in a timely, efficient, innovative and cost-effective manner.

Australia is one of the first jurisdictions to face, head on, the challenges of simultaneously:

- satisfying consumers and the community that the energy prices they pay, the service they receive and the change they allow are in their best interest
- managing the efficient integration into its power system of a considerable amount of variable renewable technologies while retiring large quantities of conventional fossil fuel generation.

This review's observations and recommendations reflect on an overall assessment of the extent to which Australia's energy policy is calibrated to meet these challenges. The review has focused on government policy responses to address the short-term challenges facing reliability and affordability. It has also focused on the medium-term challenges associated with making more timely progress on the market design for the NEM.

The ESB has advanced reforms favouring substantial investment in electricity transmission networks across the NEM, supported by the AEMO's Integrated System Plan, state-based renewable energy zones and a revision of the congestion management rules, the introduction of essential system services and scheduling mechanisms, and various amendments to wholesale market rules to permit direct integration of distributed energy resources and flexible demand.

For Australia's NEM market design, the IEA recommends adopting an implementation plan as a co-ordinated policy strategy for the decarbonisation of Australia's national electricity mix and encourages energy ministers to continue to actively oversee the progress and implementation of the National Energy Transformation Partnership, with the support and advice of the market bodies.

First, the partnership needs to develop an objective, comprehensive and adaptable policy framework for decarbonising Australia's electricity system and achieving net zero emissions by 2050. In particular, the framework should seek to facilitate efficient and timely private sector participation and investment, including providing greater clarity around the timing of capacity additions and retirements. To date, there is no coal retirement schedule and investment in gas-fired power generating capacity and battery storage has remained tight. The new capacity investment scheme, adopted by the EMM in December and designed as a contract for difference auction will provide an important mechanism for the NEM to contract dispatchable capacity in the transition to the net zero power system transformation.

Second, the reformed arrangements should enable industry participants and customers to flexibly adapt how they interact within the NEM. A comprehensive, longer term re-envisioning of the market will be beneficial so that the electricity market can be truly centred on serving consumers and release the full potential of new technologies (digital and power) and evolving business models. This long-term vision could help guide related short- and medium-term market and governance reforms.

Third, the IEA notes that the NEM governance framework is complex, with a large number of institutions and relatively unwieldy reform processes. The AEMC's rule changes have led to the creation of many small new ancillary services markets with considerable potential for market power and dominance by major players. NEM entities struggle to efficiently integrate new technologies and business models and take decisions and approvals in a timely way. Roles, functional responsibilities and related accountabilities of ministers (federal, state and territory) and the NEM market institutions can overlap and be overly complex, while there appears to be some significant gaps. Incentives for efficient and effective governance will be weakened where the institutions' roles, responsibilities and accountabilities are not effectively aligned. The need for the ESB co-ordination stems mainly from that. For example, the AEMC does not have the authority to propose rule changes, but it is accountable for the quality of the rules. The Australian Government should consider, through the energy ministers, reviewing the NEM governance and streamlining the framework, for instance, by creating an Energy Sector Transformation Commission (building on the ESB's, the AEMC's and the AER's expertise), to improve efficiency, effectiveness, co-ordination and accountability to stakeholders.

Fourth, electricity security needs to be reinforced and learning from the crisis must happen quickly. Since the 2017 Finkel Review, market reforms have progressed in several areas under the ESB's lead. This has also led to a stronger reliance on governments', regulators' and sector institutions' interventions to maintain electricity security. For example, the Retailer Reliability Obligation was introduced in 2019 and can be activated by the AEMO on a jurisdictional basis to address identified reliability gaps. In the context of the current energy crisis, retailers struggle with solvency issues and may not be the best placed to carry the Retailer Reliability Obligation. In December 2022, energy ministers agreed in principle to introduce a Commonwealth Capacity Investment Scheme, which will underwrite investment in zero emissions capacity and storage technologies based on a tender process. The new scheme is to be operational in the second half of 2023.

Compared to market operators in other jurisdictions, the rules of the NEM include greater powers for the AEMO to directly intervene at times of market stress. This includes applying a wholesale market price cap and a price floor, directing generators to run (which triggers generators' rights to apply to the Australian Energy Market Commission for compensation),

directing load shedding, and suspending the market. These AEMO directions come at a rising and very large cost. The RERT is a function conferred on the AEMO that allows it to procure out-of-market reserves. However, the NEM has no obligatory arrangements for power generators to hold oil/gas/coal fuel in storage.

Australia's east coast gas market has seen inadequate supplies over several years, since the start-up of LNG exports (see Chapter 9). The low availability of gas and its rising prices had a strong impact on the role of gas as key flexibility source. Australia is testing available options, ranging from export controls targeting spot sales or temporary domestic "reservation" policy, like the one in Western Australia, through to direct price control and/or ongoing price regulation of the value chain.

Moving from crisis intervention to a new reliability provision is essential. The 2016 South Australia blackout was the first warning that an orderly power system transformation will require more careful management, including updating the NEM's reliability. The June 2022 electricity crisis reinforces the urgency and the need for more predictable and objective-based government interventions. Based on the AEMO's and the AER's analysis of the situation and its upcoming recommendations, the government should accelerate work on the reliability setting, including work through the AEMC panel's quadrennial Reliability Standard and Settings Review, in accordance with the National Electricity Rules.

Recommendations

The government of Australia should:

Building on the National Energy Transformation Partnership, agree on an implementation plan to deliver the transition jointly with states and territories in three key areas:

- ☐ **Short-term energy crisis measures to support affordability and security:**
  - > Activating energy efficiency and demand-side actions by consumers (industry and households) to save electricity, notably during peak hours.
  - > Promote swift gas market reforms towards the deployment of low emissions gases and ensure the temporary nature of the regulation of domestic gas pricing through the Australian Competition and Consumer Commission.
  - > Adopt measures to improve liquidity for retailers.
- ☐ **Adopt a roadmap for the National Electricity Market power market design for net zero emissions:**
  - > Support co-ordination for greater alignment of national, state and territory policies, incentives and investments to achieve the targets and standards, to ensure proper planning and preparation for the retirement of coal generation.
  - > Streamline market governance and effective co-ordination through an Energy Sector Transformation Commission (with all market bodies and the Energy Security Board) to support new markets and services so that the National Electricity Market (NEM) can be truly centred on serving consumers and release the full potential of new technologies (digital and power) and business models and ensure greater clarity, independence, transparency and accountability.

- **Review power system security in the National Electricity Market based on the following actions:**
  - Assess jointly with states and territories, market participants, and consumer representatives how the NEM reliability standard is set to ensure it meets stakeholders' expectations regarding reliability and cost.
  - Agree on a transparent and accountable allocation of key responsibilities for delivering the shared responsibility of power system security, including efficient and least-cost (potentially competitive) procurement of the necessary resources to deliver the prescribed level of reliability in each region.
  - Review the June 2022 NEM power crisis and assess the effectiveness of the NEM and its market institutions in delivering efficient, timely and effective market and regulatory responses, notably from industrial, commercial and residential consumers.
  - Undertake comprehensive assessments of risks to the security of electricity and upstream fuel (coal and gas) supply, including those due to extreme weather and climate events. Seek assurance from the Australian Electricity Market Operator and all relevant stakeholders that necessary contingency plans are in place for managing multiple credible contingency events, including those with the potential to impact different generation sources, regions and network infrastructure.

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8. Coal

Key data

(2021)

Production: 273.8 Mt, 11 008 PJ, -10% since 2010

Net exports : 234.6 Mt, 9 813 PJ (0.3 Mt imports, 234.9 Mt exports)

TES: 41 Mt, 1 727 PJ (production + net imports + 1.78 Mt stock changes)

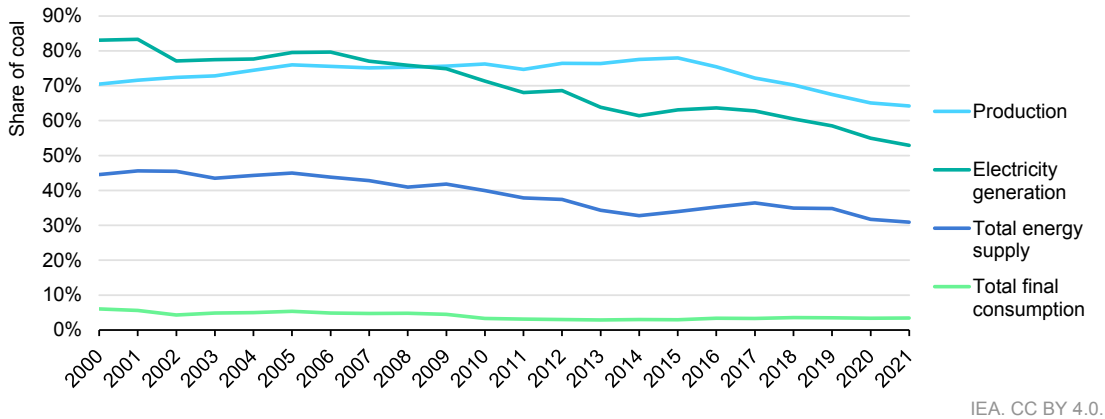
Share of coal: 64% of energy production, 32% of TES, 52.9% of electricity generation and 4% of TFC

Consumption by sector: heat and electricity generation 93%, industry 7%

Overview

In 2021, Australia was the fifth-largest hard coal producer after China, India, the United States and Indonesia. Not only does Australia have vast coal resources, but it is developing its reserves for export. Coal dominates Australia's energy system, accounting for 64% of domestic energy production, 32% of TES and 53% of electricity generation, down from 80% in 2005 (Figure 8.1). While the role of coal in power generation has been in decline, in 2021, Australia had the second-highest shares of coal in energy production and electricity generation among IEA member countries.

Figure 8.1 Share of coal in different energy flows in Australia, 2000-2021



Coal dominates Australia's energy system, accounting for two-thirds of domestic energy production, one-third of total energy supply and over half of power generation.

Notes: 2021 data are provisional; TFC data are unavailable for 2021.

Source: IEA, (2022).

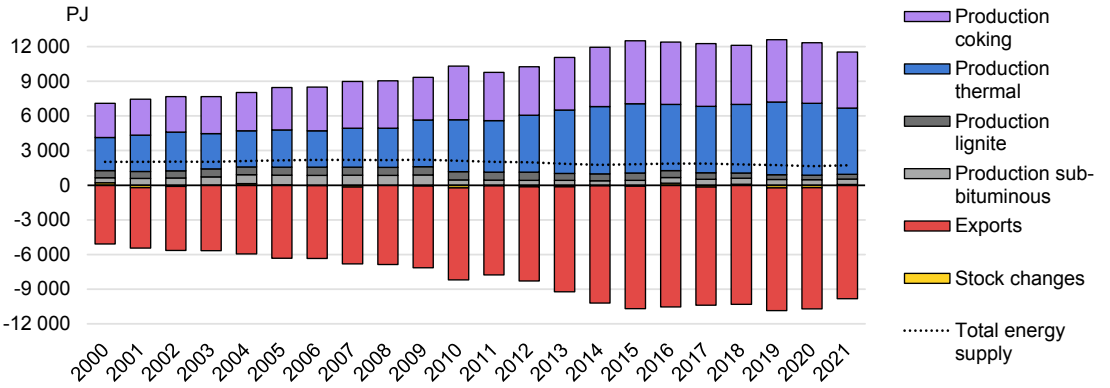
From 2010 to 2020, the share of coal increased and then started to drop in energy production (from 76% to 65%), TES (from 40% to 30%) and electricity generation (from 71% to 55%). Conversely, coal slightly increased in TFC (from 3% to 4% in 2020).

Coal reserves, production and supply

Australia's recoverable economic demonstrated hard coal resources were 75 428 Mt, the second-largest in the world, accounting for approximately 10% of world economic resources (Geoscience Australia, 2021). Australia's recoverable economic demonstrated lignite resources were 73 865 Mt, the fourth-largest in the world, accounting for approximately 24% of world economic resources of lignite.[13]

In 2020, Australia had 91 operating hard coal mines, three operating lignite mines and more than 200 coal deposits. Most of Australia's hard coal mines are in Queensland (67%) and New South Wales (30%). Lignite operating mines are concentrated in Victoria's Gippsland Basin, mainly in the Latrobe Valley (Geoscience Australia, 2021).

Figure 8.2 Coal production and total energy supply by type in Australia, 2000-2021



After Indonesia, Australia is the world's second-largest coal exporter but comes first for coking coal.

Notes: PJ = petajoule. 2021 data are provisional. Imports were negligible between 2010 and 2021, between 1 PJ and 8 PJ per year.

Source: IEA, (2022).

Over the past decade, Australian hard coal production has grown by a compound average annual rate of 1.9%, from 348 Mt in 2010-2011 to 420 Mt in 2020-2021. The two main types of hard coal products are coking coal, used for steel making, and thermal coal, used for energy production. In 2020-2021, Australia produced 170 Mt of coking coal and 237 Mt of thermal coal. Australian lignite production declined by a compound average annual rate of 5.4%, from 73 Mt in 2010-2011 to 42 Mt in 2019-2020.

The Australian government projects Australian production of metallurgical coal to increase to 197 Mt and thermal coal to 281 Mt in 2025-26. Major projects expected to contribute to the increase over the next five years include the Olive Downs, Mangoola, United-Wambo

[13] The IEA uses the international terminology of lignite (brown coal) and hard coal (black coal for thermal and metallurgical coal).

and Carmichael mines. The Bravus Carmichael Coal started coal production from the Galilee Basin in Queensland in late 2021 and began exporting coal in early 2022. The mine is expected to produce 10 Mt per annum of coal. The mine will provide hard coal to India. The Galilee Basin has hard coal recoverable deposits of 11.4 billion tonnes (approximately 15% share of Australia's total).

Metallurgical coal prices reached historic highs in late 2021 as supply shortages met strong Chinese demand and rebounding global industrial production. The Australian premium hard coking coal price is forecast to ease from an average of around 404 USD/t in 2021-2022 to 231 USD/t by 2023-2024. Production is expected to rebound from a low of 162 Mt in 2021-2022 to reach 180 Mt by 2023-2024 (DISR, 2022).

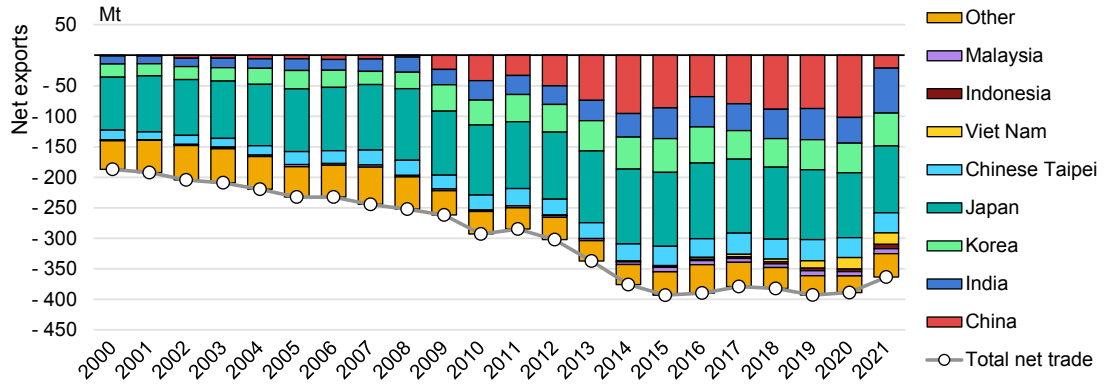
Figure 8.3 Coal production regions in Australia

Source: IEA, (2022).

Coal trade

Australia is currently the world's largest exporter of coking coal. Within hard coal, thermal coal accounted for around 55% of Australia's coal exports in 2021-2022, with metallurgical coal accounting for the remainder. Exports go mainly to Asian partners, such as Japan, Korea, India and Chinese Taipei (in order of significance). Since 2021, Australian exports to China have been banned by import restrictions imposed by the Chinese government. Before the ban, in 2020, 69% of Australian exports had gone to China. Only 24% of metallurgical coal went to China, with India (21%), Japan, the European Union and Korea being the other key importers. The European Union, Japan and Korea also imported Australian iron ore.

Figure 8.4 Australia's coal net trade, 2000-2021



Australia's coal exports serve Asian markets, mainly China, but exports were stopped in 2021 following the imposition of an import ban.

Note: Mt = million tonnes.

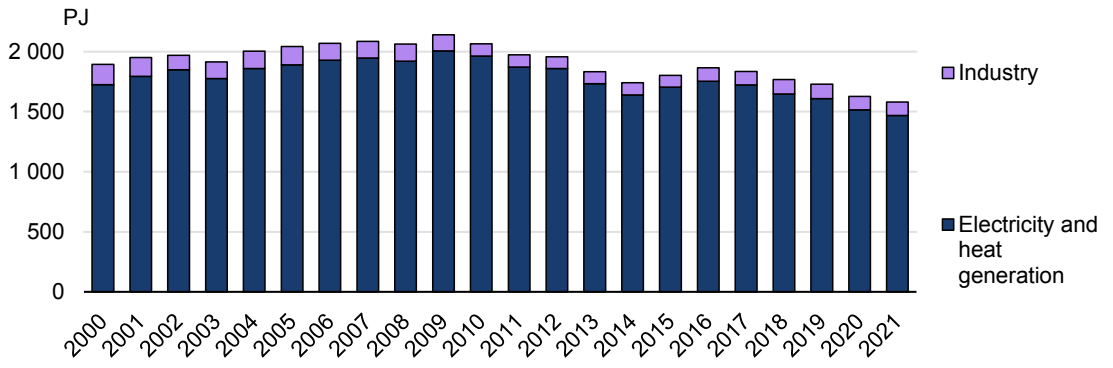
Source: IEA, (2022).

While global coal trade rebounded in 2022, the IEA's latest *Coal Market Report* forecasts a decline through 2025 (IEA, 2022b). The decline towards 2025 is driven by stronger domestic supply in China and India and lower coal-fired power generation in the European Union. However, Australia's exports are to contract only marginally and met coal exports are forecast to remain strong, with Australia dominating global trade.

Coal demand

Coal consumption has declined by 23% over the last ten years (from 2 254 PJ in 2009-2010 to 1 684 PJ in 2020-2021). This was mainly due to the closures of coal-fired electricity generation. Over the past 15 years, coal-fired electricity generation has gradually been displaced by renewable generation and natural gas, declining from 181 TWh in 2004-2005 to 140 TWh in 2020-2021. The decline in lignite coal-fired electricity generation has been more pronounced (only Victoria uses lignite) than the decline in hard coal-fired electricity generation. Large in size, the closure of the Playford B power station in 2015, the Northern power station in 2016 and the Hazelwood power station in 2017 have resulted in a decline of lignite-fired electricity generation by 40% over the last decade. Conversely, the decline in black coal-fired electricity generation has been more modest, at 9.6%. In 2021, coal still accounted for 53% of power generation.

Figure 8.5 Coal demand by sector in Australia, 2000-2021



Over the past 15 years, coal-fired electricity generation has seen less favourable economics and has been displaced by renewable generation and natural gas.

Note: PJ = petajoule.
Source: IEA, (2022).

Coal policy and transition

The outlook for coal is impacted by Australia's legislated goal of reaching net zero by 2050 and 43% of emissions reductions by 2030, as well as the changing economics of power generation. No date is marked for a final phase-out of coal electricity plants or coal mine closures. The government requires coal-fired generators to provide a three and a half year notice of their closure decision. However, this short notice is insufficient to signal timely investment in a new dispatchable plant.

Coal in power generation

The Australian Government aims to reach an 82% share of renewable energy in the national electricity generation by 2030. This implies a fast decline in coal use in power generation, which started a decade ago. It is important to note that Australia's power plants are large, notably in New South Wales, reaching 1-3 GW (see Table 8.1).

In the NEM, total installed coal-fired power generation in 2021 was 22.7 GW, down from its peak of 30 GW in 2011. South Australia phased out coal in power generation in 2016. Over the past decade, around 5 GW of coal-fired power generating capacity has been decommissioned. In 2022, New South Wales, Queensland, Victoria and Western Australia were the states with coal-fired generation. South Australia, the Northern Territory, the Australian Capital Territory and Tasmania do not have coal generation in their domestic generation mix but benefit from the firming capability of coal-fired power plants within the interconnected grids. The Western Australian government announced in 2022 that state-owned Collie station will fully exit the market by 2027 and Muja station by 2029, leaving Western Australia with one remaining plant, the privately owned Bluewaters station (Table 8.1). Victoria announced it aims to reach 95% of renewables in its power mix by 2035.

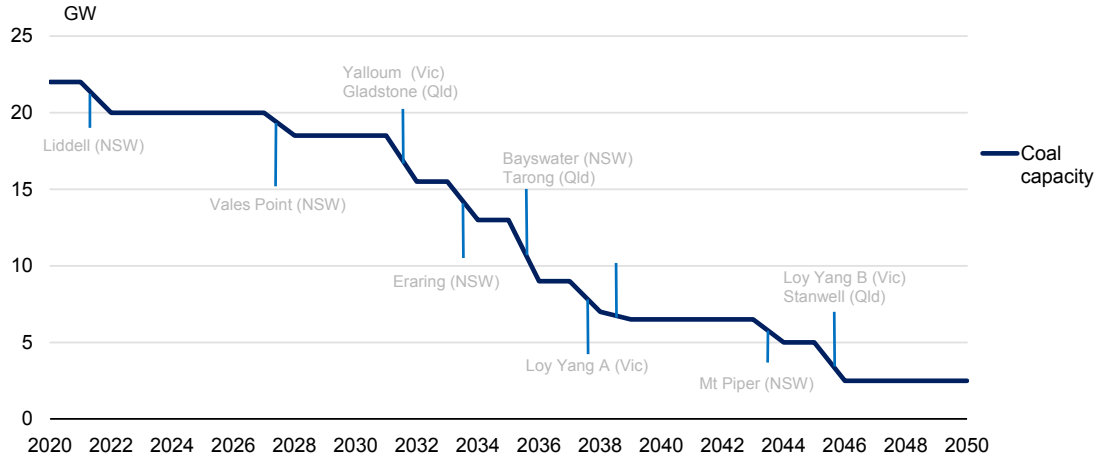
Table 8.1 Australia's operating and closed coal power plants

State	Station	Fuel type	Year of commissioning	Announced decommissioning	Age (years)	Capacity (MW)
NSW	Eraring	Black coal	1982-1984	2025	32-34	2 880
NSW	Bayswater	Black coal	1982-1984	2035	32-34	2 640
NSW	Liddell	Black coal	1971-1973	2023	43-45	2 000
NSW	Mt Piper	Black coal	1993		23	1 400
NSW	Vales Point B	Black coal	1978		38	1 320
VIC	Loy Yang A	Brown coal	1984-1987	2048	29-32	2 210
VIC	Yallourn W	Brown coal	1975, 1982		34-41	1 480
VIC	Loy Yang B	Brown coal	1993-1996		20-23	1 026
QLD	Gladstone	Black coal	1976-1982		34-40	1 680
QLD	Tarong	Black coal	1984-1986		30-32	1 400
QLD	Stanwell	Black coal	1993-1996		20-23	1 460
QLD	Callide C	Black coal	2001		15	810
QLD	Millmerran	Black coal	2002		14	851
QLD	Kogan Creek	Black coal	2007		9	750
QLD	Callide B	Black coal	1989		27	700
QLD	Tarong North	Black coal	2002		14	443
QLD	Yabulu (Coal)	Black coal	1974		42	37.5
QLD	Gladstone QAL	Black coal	1973		43	25
WA	Muja	Black coal	1981, 1986	2029	30-35	1 070
WA	Collie	Black coal	1999	2027	17	340
WA	Bluewaters 1	Black coal	2009		7	208
WA	Bluewaters 2	Black coal	2010		6	208
WA	Worsley (Alumina)	Black coal	1982-2000		16-34	135
Total	**operating plants**					**25 073.5**
NSW	Munmorah	Black coal	1969	July 2012	43	600
NSW	Redbank	Black coal	2001	August 2014	13	143.8
NSW	Wallerawang C	Black coal	1976-1980	November 2014	38	1 000
VIC	Morwell	Brown coal	1958-1962	August 2014	52-56	189
VIC	Anglesea	Brown coal	1969	August 2015	46	160
VIC	Hazelwood	Brown coal	1964-1971	March 2017	45-52	1 600
QLD	Collinsville	Black coal	1968-1998	December 2012	14-44	180
QLD	Swanbank B	Black coal	1970-1973	May 2012	42	500
SA	Northern	Brown coal	1985	May 2016	31	546
SA	Playford	Brown coal	1960	May 2016	56	240
Total	**closed plants**					**5 158.8**

Notes: NSW = New South Wales; VIC = Victoria; QLD = Queensland; WA = Western Australia.

In March 2022, Origin Energy announced that the country's biggest coal-fired power station Eraring is set to close seven years earlier than planned, already in 2025. The remaining units at the Liddell Power Station in New South Wales will shut down by April 2023, according to the owner AGL, when the power station fully closes. The site will be converted into a low-carbon industrial energy hub.

Figure 8.6 Australia's National Electricity Market coal capacity and announced decommissioning, 2020-2050



The outlook for coal is impacted by Australia's legislated goal of reaching net zero by 2050 and a 43% emissions reduction by 2030, as well as the changing economics of power generation.

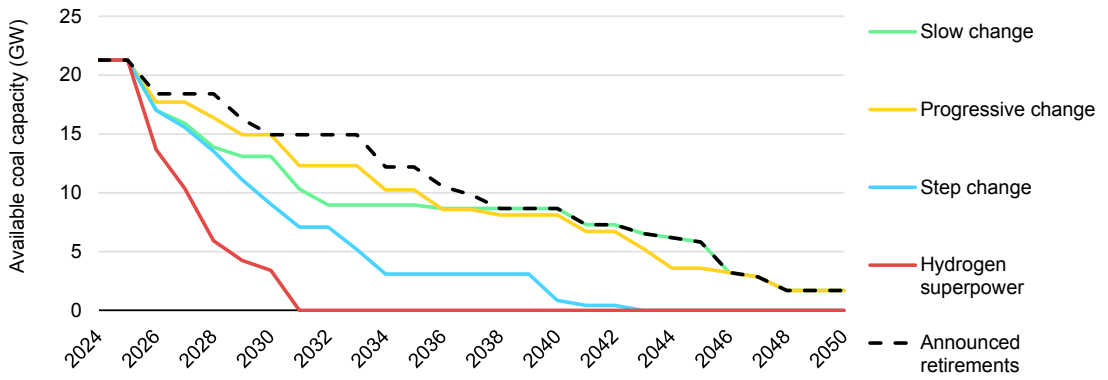
Notes: GW = gigawatt; NWS = New South Wales; Vic = Victoria; Qld = Queensland.

Source: IEA, (2022) analysis based on an expected 50-year technical lifetime.

The AEMO's Integrated System Plan 2022 reports that over the next two decades, around 16 GW of thermal generation (including 61% of the current coal fleet) is expected to retire with a total exit of coal use in power generation by 2043 (Figure 8.6).

Retirements in the AEMO's Step Change Scenario are broadly aligned with the Paris Agreement but not yet with a net zero pathway. The Step Change Scenario forecasts the withdrawal of 14 GW of the 23 GW current coal capacity in the NEM by 2030, while coal plant owners have so far only announced 8.4 GW in withdrawals. Compared to the commercially motivated announced and forecasted closures and plant lifetimes, the fast and steep decline of dispatchable generation in a very short time frame becomes apparent, which raises the lack of dispatchable capacity (see Chapter 7).

Figure 8.7 Scheduled closure profile of coal-fired generators in Australia, 2024-2050



Australia's system operator forecasts several transformation scenarios which would see a steep decline in dispatchable capacity due to early coal plant closures.

Note: GW = gigawatt.
Source: AEMO, (2022).

Box 8.1 International experience in phasing out coal from the energy system

Focusing on the coal transitions to net zero, the IEA has developed an exposure index that takes into account the dependence of the economy and employment, the role of coal in the domestic energy mix and end-use sectors.

After iron ore, in Australia, the coal industry was the second-largest export earner in 2020-2021, valued at nearly AUD 40 billion and contributing around 170 000 export-oriented jobs, most of which are in Queensland and New South Wales. Among IEA member countries, Australia had the second-highest shares of coal in its domestic energy production and electricity generation and the third-largest share of coal in TES in 2020. The share of coal has been declining across the energy system but remains predominant notably in power generation, accounting for half of the electricity generated. Only Poland has more coal use in power generation.

Given the large role of coal in the country's export revenues and economy, Australia has a relatively high exposure. Coal transitions are unavoidable but must be orderly to manage the implications in economic, social and environmental terms.

International experience confirms that coal plants may close well ahead of identified closure times, as carbon prices start to increase, the relative fuel costs change as renewables see stark cost declines and energy markets transition, with major implications for reliability. The retrofitting with CCUS, the repurposing or fuel switching of units or co-firing (with biomass) can support electricity reliability, avoid stranded assets, and maintain site and grid connection for the installation of clean power investment (battery storage) while meeting environmental regulations.

Sources: IEA (2022c).

Coal in industry and coal mining

One way that Australia aims to reduce GHG emissions from coal production and combustion is by making use of CCUS technologies. Australia's industry is developing CCUS facilities and is investing in new mines. Several CCUS and hydrogen projects are linked to abating emissions from coal use in power and industry. However, the current Government so far has made it clear it does not support the extension of the ARENA/CEFC funding to CCUS (see Chapter 6).

Coal royalties surpassed AUD 5.2 billion in 2019-2020 and AUD 3.1 billion in 2020-2021 (due to Covid-19). The coal sector accounts for around 51 000 direct jobs and 120 000 indirect jobs in engineering and construction, among others. Most of these jobs are in regional areas in Queensland and New South Wales.

With regard to coal mining, previous governments vowed to work to keep coal mines operating for as long as possible while diversifying their export markets and products towards critical minerals. The Australian Government committed AUD 20.1 million in the 2021-2022 Budget to diversify Australia's resources export markets through the Global Resources Strategy. The strategy seeks to analyse opportunities in both new and existing export markets, identify the barriers to realising these opportunities, and deliver targeted measures to address the identified barriers. The objectives also include supporting R&DD in the industry to scale up the commercialisation of alternative uses for high-intensity emissions resources.

The Australian Government has some funding or support programmes specifically for some coal regions to move to new industries. Nevertheless, companies are progressively diminishing investments in this sector following global market trends towards decarbonised energy sources. Investor and financial support for the coal industry is in decline. Australian coal projects face difficulties attracting public equity and insurance, with domestic banks, companies, superannuation funds and insurers moving away from financing or insuring fossil fuels. For an increasing number of companies, climate risk represents a significant material investment risk in their portfolios. Since 2016, some of Australia's prominent coal producers have been looking to divest from coal assets. Rio Tinto completed the sale of all its coal assets in August 2018. In 2022, BHP confirmed it will close its last remaining Australian thermal coal asset (Mount Arthur) by 2030.

Assessment

In 2021, Australia was the fifth-largest coal producer after China, India, the United States and Indonesia. Australia is the world's largest exporter of coking coal and the second-largest of thermal coal.

Over the past decade, Australian hard coal production has grown by a compound average annual rate of 1.9%, from 348 Mt in 2010-11 to 420 Mt in 2020-2021. The two main grades of hard coal products are metallurgical coal, used for steel making, and thermal coal, used for heat production used directly or for the production of steam. In 2020-2021, Australia produced 170 Mt of metallurgical coal and 237 Mt of thermal coal.

In recent years, total Australian coal production and thus exports have been negatively impacted by the global Covid-19 pandemic, reduced labour availability and adverse weather conditions from the La Niña phenomenon with heavy rainfalls and severe storms, as well as the unofficial import ban imposed by China (on metallurgical coal imports).

Russia's invasion of Ukraine has supported a short-term global revival of coal use, notably in Europe, which needs to replace significant volumes of Russian gas. As a consequence of Russia's steep gas supply cuts, the share of Russian gas in the European Union's gas demand fell from 40% in 2021 to 9% by the end of 2022. This has also led to a restructuring of global coal trade, with Russian discounted coal being traded in Asia, with strong price impacts also felt in Australia. Australian high-grade thermal coal prices rose to a record of 443 USD/t in September 2022, as flooding blocked coal production and transport was not able to fully meet increased demand by Japan and utilities in Europe and Northeast Asia, who sought to obtain supplies of non-Russian coal. This has led to a surge in coal prices also in the domestic market and the June 2022 coal crisis in Australia's NEM.

Amid important power plant closures (Hazelwood), lignite production in Australia declined by a compound average annual rate of 5.4%, from 73 Mt in 2010-11 to 42 Mt in 2019-2020. Metallurgical coal, on the other hand, reached historic highs in late 2021 as supply shortages coincided with rebounding global industrial production.

Major projects expected to contribute to the increase in Australian coal production over the next five years include the Olive Downs, Mangoola, United-Wambo and Carmichael mines. Carmichael will ramp up production in the coming years. The Bravus Carmichael Coal mine started producing coal from the Galilee Basin in Queensland. Bravus began exporting coal in early 2022. The mine is expected to produce 10 Mt per annum of coal. The mine will provide lignite to India, among others. The Galilee Basin has hard coal recoverable deposits of 11.4 billion tonnes (approximately a 15% share of Australia's total).

There is uncertainty about the future of new coal mines and the exact time of coal-fired power plant closures in the coming decade. South Australia phased out coal in power generation in 2016.

The government has developed a pathway and policies for transitioning the energy sector to net zero through the Powering Australia plan, the Annual Climate Change Statement 2022 and the National Energy Transformation Partnership. The October 2022 Federal Budget detailed an array of these policies, including the Powering the Regions Fund to ensure traditional industries in regional Australia can harness the economic opportunities of decarbonisation, funding a Hydrogen Hub in Townsville, as well as funding for community batteries and solar banks. This will also have implications for the domestic coal mining sector.

In the short term, Australian coal exports have increased and notably Asia sees strong investment in new coal generation. In the medium term to 2026-27, Australia's thermal coal production is forecast to decline and then recover slightly, remaining close to the 2019 level (197-203 Mt range). Australian metallurgical coal exports are expected to rise, from 162 Mt in 2021-2022 to 180 Mt in 2023-2024, with increased production in New South Wales and Queensland. Up to 2030, it is expected to be difficult to increase production from current levels to provide additional exports to global markets in response to demand for increased coal supply.

In line with net zero targets, the Australian coal industry does not expect major investment in additional coal production, as new coal mines under development will largely replace those slated for closure. The government is open to maintaining coal exports, stating a willingness to supply coal as long as its trade partners require it.

To stay within reach of the Paris Agreement's 1.5°C goal, emissions from coal use have to peak and decrease dramatically by 2030. Australia's trading partners have put forward NDCs and may well see a decrease in their coal use, as many importing countries and companies have committed to net zero emissions by 2050.

The Australian coal industry is promoting and investing in low emissions technology developments, such as CCUS, hydrogen production using gasification and CCUS technology from lignite. Since 2008, the government has invested AUD 790 million in CCUS and related low emissions technologies. Australia is developing a National CCUS Technology Emissions Abatement Strategy to improve policy frameworks and co-ordinate the deployment of CCUS hubs and technologies. Australia aims to address GHG emissions from coal combustion by making use of CCUS technologies. There is one project in power generation, the Glencore CCUS project, partnering with J-Power, Marubeni and others. Australia's industry is developing CCUS facilities and investing in new mines. There is no public investment in CCUS to date, as ARENA's and the CEFC's mandates do not allow for investment in this field. Given the ageing coal-fired power fleet, the investment case for new CCUS retrofits is uncertain.

Curtailing emissions from the mining sector, notably methane emissions, the Australian coal industry is continuously developing mitigation and utilisation measures, methodologies and guidelines. While the Australian coal industry has focused on rich sources of methane and deploying commercially available technologies to reduce emissions as far as possible in underground operations, there are currently no commercially available means for abating fugitive emissions from surface open cast mines, which account for 80% of the total emissions. Despite Australia's recent commitment to join the Global Methane Pledge, no national target exists, though Australia is implementing a range of methane reduction policies including funding under the National Reconstruction Fund, Powering Australia plan and Methane Emissions Reduction in Livestock Program.

In the power sector, the Australian Government announced a goal of 82% of renewable electricity in Australia's national mix. However, uncertainty remains about the pathway for coal use and the speed of retirement. In its 2022 ISP, the AEMO forecasts that 14 GW of the 23 GW current coal capacity in the NEM will be retired by 2030, while coal plant owners have so far announced the retirement of only 8.4 GW. Lignite use in power generation is expected to end in 2032 according to the ISP 2022. The Australian Government requires a 3.5-year notice period for coal-fired power plant owners to notify the government of a plant closure. As a result, there is considerable uncertainty about the pace of clean energy investment at the right time and location.

Commendably, the government is introducing an emissions objective under the National Energy Law, National Energy Retail Law and National Gas Law which can reassure investors in the power sector decarbonisation. Greater certainty is necessary for the orderly transition of the coal plant closures and its impact on reliability and adequacy in the power sector.

In light of Australia's net zero pledge, the government needs to ensure the power sector's transition to net zero is taking place in a timely, secure and cost-effective way. Several options are available to address the carbon legacy of Australia's coal-fired power plants: early retirements, retrofitting with CCUS, fuel switching (to natural gas or other lower carbon fuels) or repurposing to clean power investment at the same site. In a net zero context, not all these options will be cost-effective or desirable in the medium to long term.

Recommendations

The government of Australia should:

- ☐ Ensure that coal-fired power plant closures are properly planned with states and territories, the Australian Electricity Market Operator, and power plant owners. Effective planning should prepare for job shifts and new jobs for displaced workers, and an evaluation of the capacity additions needed in the power system, including repurposing the same site, taking into account the power system stability and reliability such as inertia, reactive power and the cost required.
- ☐ For industry, follow through with the announced deployment strategy for CCUS in 2025, supporting the development of CCUS, hydrogen clusters/hubs and removing other barriers to implementation.
- ☐ Promote research, development, monitoring techniques and investment in technologies to mitigate emissions from the mining sector, notably methane emissions.
- ☐ Promote the shift in skills and resources from coal mining to the mining of critical minerals and other low emissions technology sectors (green steel, cement, etc.) and assess requirements for regulatory measures or financial means to assist communities and workers.

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9. Natural gas

Key data

(2021)

Natural gas production: 156 bcm; +187% since 2010

Exports: 103.4 bcm, +353% since 2010

Share of natural gas: 29% of energy production, 28% of TES, 19% of electricity generation, 17% of TFC

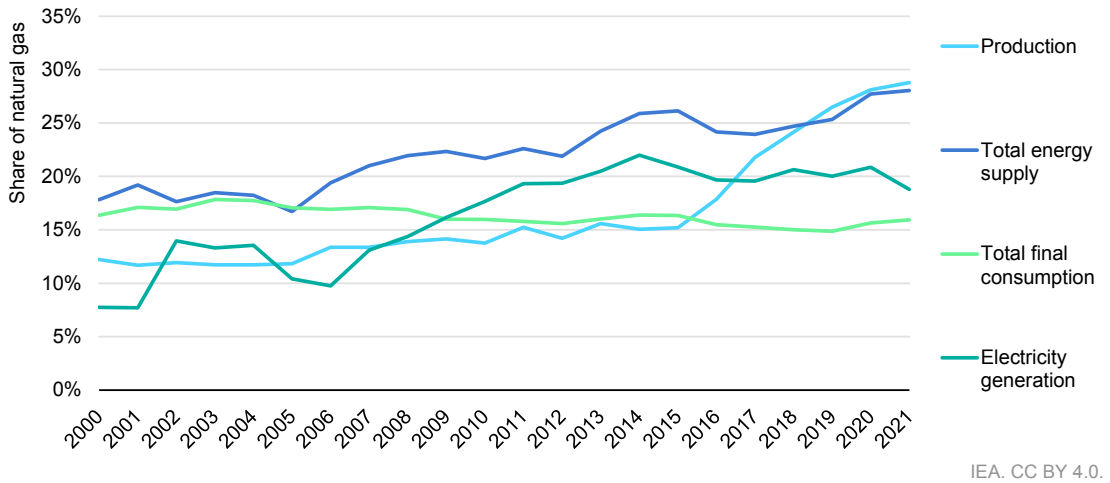
Inland consumption: 39.7 bcm

Demand by sector: electricity and heat generation 33.9%, industry 23.3%, residential buildings 10.8%, service sector buildings 2.9%, transport 1.3%

Overview

With exports of 103 bcm in 2021, Australia was the world's largest LNG exporter, followed by Qatar and the United States. Thanks to the steep increase in gas production, up by 187% since 2010, LNG exports have increased by 353% since 2010. Australia's gas production has also served a significant domestic gas market of around 40 bcm and met the growing needs for gas in power generation (19%) and in TFC (16%).

Figure 9.1 Share of natural gas in Australia's energy system, 2000-2021



Since 2015, natural gas production, TES and electricity generation from natural gas have increased.

Source: IEA, (2022a).

Gas supply and demand

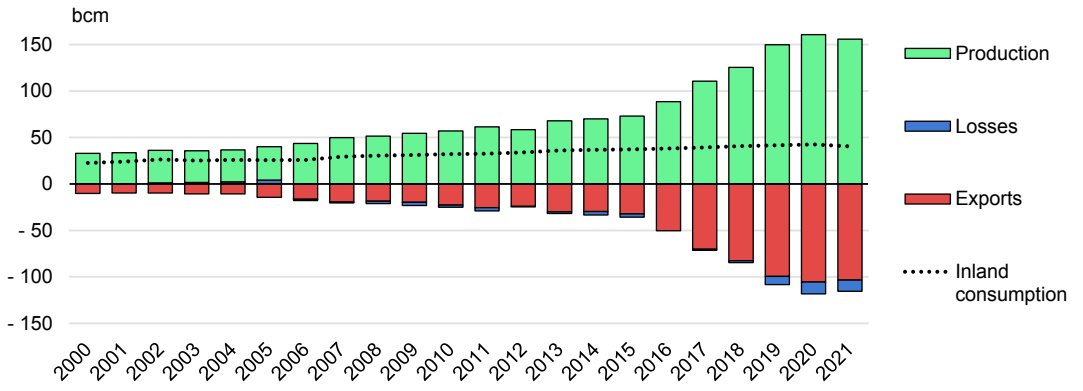
Production

In 2021, Australia's natural gas production was 156 bcm, making it the seventh-largest producer in the world. Natural gas production has increased substantially in recent years, driven by a rapid expansion of the Australian LNG industry on both the east and west coasts.

The most significant production of conventional gas occurs in the basins of the North West Shelf, off Western Australia. The North West Shelf basins (Northern Carnarvon, Bonaparte and Browse) accounted for 63% of Australia's total gas production in 2021. Significant quantities of conventional gas are also produced in the Gippsland Basin (in south-eastern Australia) and the Cooper Basin (mainly in the south-western part of Queensland).

Unconventional production is dominated by coal seam gas and occurs predominantly in the Bowen and Surat Basins in Queensland, which together accounted for 25% of Australia's total gas production in 2021. Coal seam gas from the Bowen and Surat Basins is processed at three major liquefaction plants off the eastern coast of Queensland (Queensland Curtis LNG, Gladstone LNG and Australia Pacific LNG).

Figure 9.2 Australia's gas production, consumption and exports, 2000-2021



In 2021, Australia's natural gas production was 156 bcm, of which 100 bcm were exported. The role of natural gas in inland consumption is stable, reaching 40 bcm in 2021.

Note: bcm = billion cubic metres.

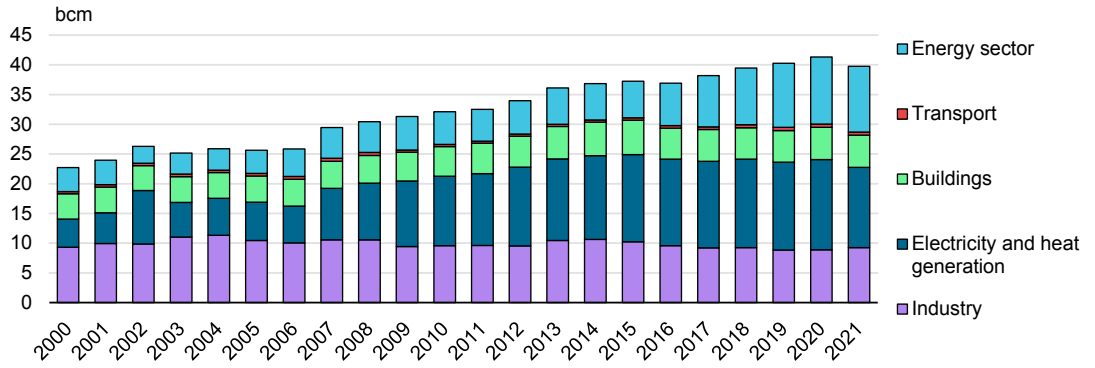
Source: IEA, (2022a).

Demand

Demand for natural gas has increased strongly in Australia in recent years, growing by over 30% from 2010 to reach 40.4 bcm in 2021 (Figure 9.3). In 2020, the latest year for which demand by sector is available, energy industry (production of LNG and mining) together with industry (manufacturing, petrochemicals etc) were the most significant source of gas demand (49%, 21 bcm), followed by electricity and heat generation (36%, 15 bcm), and buildings (14%, 6 bcm).Demand growth in the past decade has mainly been driven by energy industry sector (+38%, 6 bcm since 2010), predominantly from LNG

production and the mining sector. Demand for gas from electricity and heat generation has also grown substantially (+30%, 3.5 bcm since 2010).

Figure 9.3 Natural gas demand by sector in Australia, 2000-2021



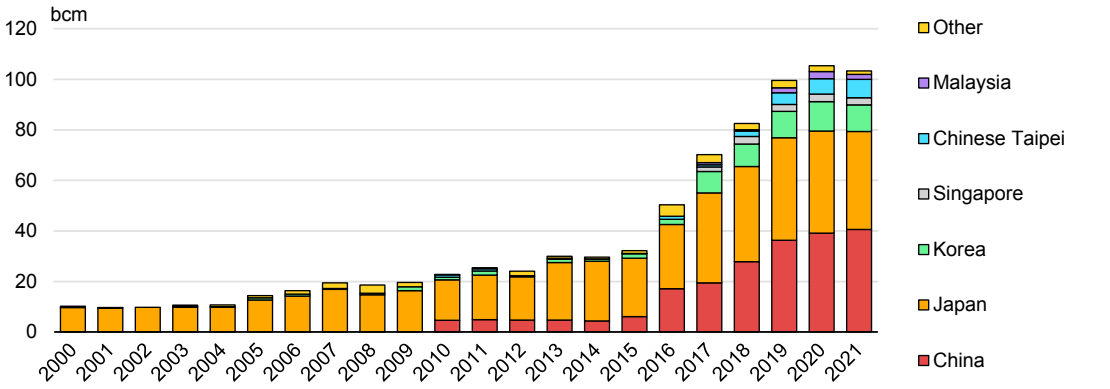
Natural gas demand has risen by 30% in the past decade, primarily due to increased demand from the LNG industry and the mining sector.

Notes: bcm = billion cubic metres. Industry includes energy sector own use (LNG plants).
Source: IEA, (2022a).

Exports

In 2021, Australia was the world's largest exporter of LNG, with exports of 103 bcm (Figure 9.4). Australian natural gas net exports have risen significantly in the past decade, up from just 24 bcm in 2010, as the LNG industry has expanded rapidly.

Figure 9.4 Australia's natural gas exports by destination, 2000-2021



Australia has become the world's largest LNG exporter, with 103 bcm of exports in 2021, most of which was sent to Asia, primarily to China and Japan.

Note: bcm = billion cubic metres.
Source: IEA, (2022a).

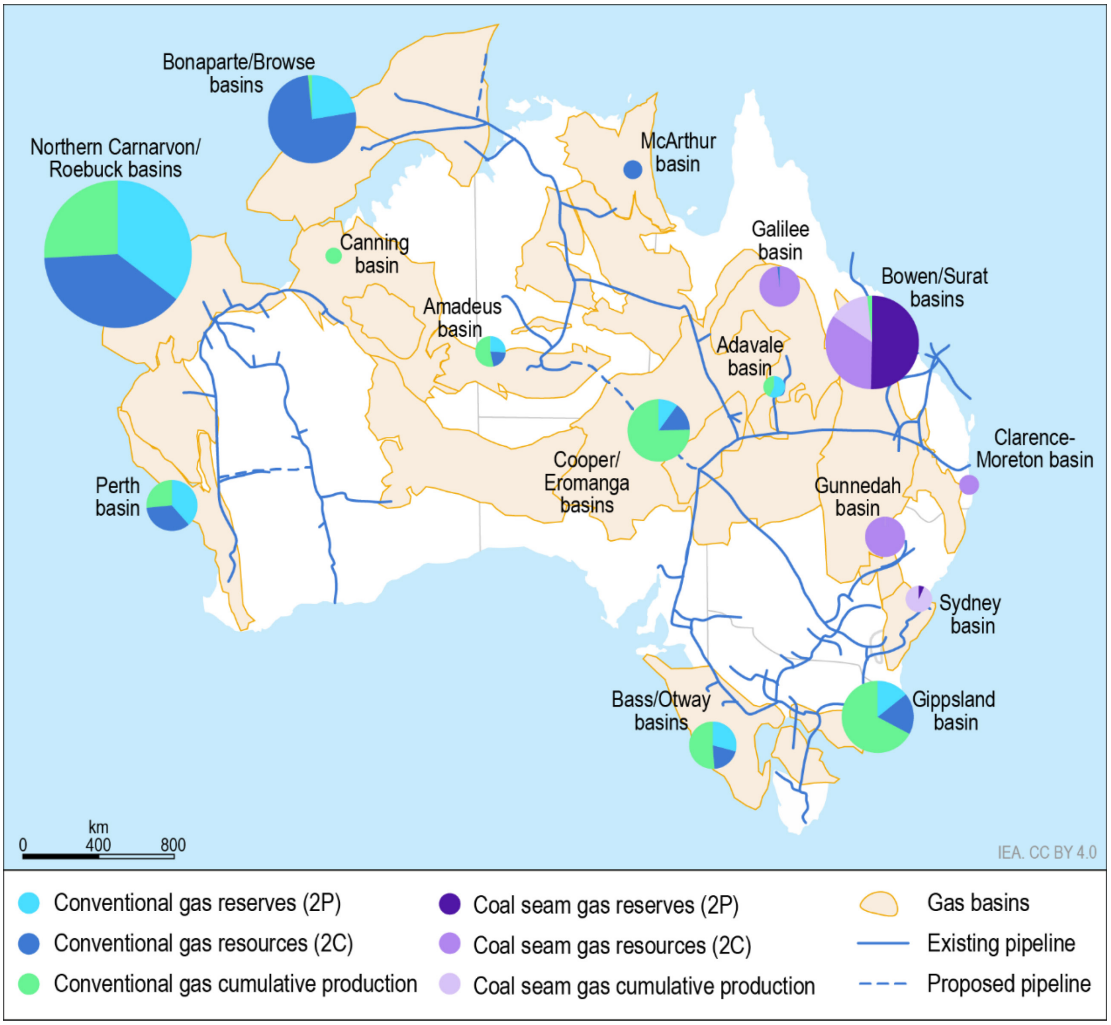
Australia primarily exports gas to markets in Asia. Japan and China are the most significant export destinations for Australian LNG, with each accounting for around 40% of the country's total gas exports in 2021. Australia's remaining gas exports went to Korea,

Malaysia and Chinese Taipei. Recently, Australian LNG is also finding its way to Europe. Australia does not currently import gas, but a number of LNG import facilities have been proposed to help resolve forecast winter shortfalls in gas supply to the south-east domestic market (see “Infrastructure section” below).

Natural gas reserves

Over the coming decade, Australian natural gas production is forecast to decrease in the east, relying on supply from a number of existing fields which are in decline. Conversely, gas production is expected to remain stable in Western Australia, thanks to two substantial new offshore fields, the Scarborough and Crux fields.

Figure 9.5 Natural gas reserves and resources in Australia



Notes: 2P reserves are defined as proven reserves plus probable reserves. 2C reserves are defined as the best estimate of contingent resources.

Source: IEA, (2022).

The Scarborough field, developed by Woodside Petroleum, is Australia’s most significant offshore natural gas project, holding reserves of around 200 bcm. Woodside Petroleum received key approvals to proceed with the project from the Australian Government and

the Government of Western Australia in April 2022. Gas is expected to be processed and exported from a second LNG train (Train 2) at the Pluto LNG onshore facility from 2026, which received FID in 2021.

Shell Australia and its joint venture partner, SGH Energy, took an FID to develop the Crux offshore gas field in Western Australia in May 2022 after receiving regulatory approvals. The Crux field is estimated to hold reserves of 550 million standard cubic feet of gas per day. Gas from the Crux field is expected to be processed at Shell's Prelude floating LNG vessel from 2027.

The most notable onshore projects are the Narrabri project in New South Wales, the Beetaloo sub-basin in the Northern Territory with its shale gas resources, and the North Bowen and South Galilee Basins in Queensland. However, all onshore projects have faced public objections and, in some instances, lack local government support.

In 2019, Australia had an estimated total demonstrated resources (all conventional and unconventional gas) of 269 206 PJ, which includes the sum of 2P reserves and 2C contingent resources. Over 90% of identified conventional gas resources are located offshore, along the North West Shelf, while unconventional reserves are constituted entirely of coal seam gas located in Queensland. While Australia is believed to have potentially substantial quantities of other unconventional gases, including shale and tight gas, the government does not have data relating to the size of unconventional reserves aside from coal seam gas, reflecting the early stage of unconventional gas exploration in Australia.

Gas infrastructure

Pipelines

Australia has more than 40 000 km of natural gas transmission pipelines. The east coast gas market is serviced by an interconnected transmission pipeline system – the East Coast Grid – that covers all Australian states and territories, except Western Australia. Around 20 major transmission pipelines transport gas to the eastern gas market.

The Northern Territory was connected to the East Coast Grid after the Northern Gas Pipeline, owned by Jemena, commenced commercial operations in January 2019. Jemena has proposed a project to double the capacity of the Northern Gas Pipeline and extend it to the Beetaloo Basin, but progression on this project is likely dependent on whether production commences in the basin.

The South-West Queensland Pipeline and the Moomba Sydney Pipeline, both owned by APA Group, play a crucial role in supplying gas from production in the north (Queensland) to states and territories in the south-east of the country, which has become increasingly important as production in the south has declined. APA Group has reached FID on a 25% expansion of the capacity of both pipelines to transport gas from Queensland to southern states and territories. The expansion will occur in two stages, with new capacity expected to come on stream in during June 2023 and June 2024, respectively. A third stage of expansion to add a further 25% transportation capacity to both pipelines is also proposed, but no FID has been taken.

APA is also planning to upgrade the Victorian Transmission System by building a 51 km high-pressure transmission pipeline and compressor station by mid-2023. This project will

address capacity constraints that limit the volume of gas that can be transported from western Victoria to demand centres in the north and east of the state.

The Eastern Gas Pipeline, operated by Jemena, runs from the Longford and Orbost Gas Plants in the Gippsland Basin in Victoria to Sydney. The Port Kembla LNG terminal is not expected to start operations until at least 2024. Modifications will be made to the pipeline to facilitate bidirectional flow from Port Kembla both north (to Sydney) and south (to Victoria).

Figure 9.6 Natural gas infrastructure in Australia

Source: IEA, (2022).

The geographically separate Western Australian Gas Market is serviced by four major natural gas transmission pipelines (all of which are interconnected), as well as several smaller pipelines. The two major pipelines are the Dampier to Bunbury Pipeline (owned by the Australian Gas Infrastructure Group [AGIG]) and the Goldfields Gas Pipeline (owned by APA Group).

Gas transmission is dominated by three pipeline operators: APA Group, Jemena and AGIG. APA Group and AGIG own and operate transmission pipelines across Australia, while Jemena is present in the eastern market only.

Pipeline access and regulation

In Australia, the owners of gas transmission are not involved in production. Gas customers must negotiate with producers to buy gas then separately negotiate with pipeline operators, making sourcing and supplying gas a cumbersome process in some cases.

Access to available pipeline capacity can be gained by using capacity trading platforms. Reforms introduced in 2019 made it easier to access unused pipeline capacity by mandating that contracted but unused capacity must be offered at a mandatory day-ahead auction. While the day-ahead auctions have improved liquidity somewhat, auction activity on some pipelines remains low, and there is considerable concern about the difficulty in accessing pipeline capacity and the ramifications for competition and pricing in the east coast market.

The Australian Energy Regulator noted that many critical transmission pipelines on key north-south transport routes often have little or no spare uncontracted capacity, making it difficult for consumers to negotiate access. It also notes that pipeline companies face little competition and therefore charge monopolistic prices. The AER regulates pipeline services in all jurisdictions except Western Australia, where the Economic Regulation Authority holds this responsibility. While all pipelines outside Western Australia are subject to the regulatory oversight of the AER, pipelines that do not provide third-party access can be exempt from regulatory requirements (Part 23 regulation). Pipelines that are regulated for third-party access can come under "light" or "full" regulation, with "lightly regulated" pipelines being able to freely determine their own access tariffs and "fully regulated" pipelines having to attain the AER's approval for their proposed access arrangements. The decision on how to regulate a pipeline is taken following an assessment of the impact on competition carried out by the National Competition Council.

Reforms to the pipeline access regulatory framework were introduced in March 2019 and September 2022.

In March 2019, a pipeline capacity trading framework started with the day-ahead auction and the Capacity Trading Platform. The day-ahead auction has been very successful in supporting trade in unnominated contracted capacity on key pipeline routes.

Consultation was undertaken during November and December 2021 on options to improve the pipeline capacity trading framework. Under the Australian Energy Market Agreement,[14] further reforms to the gas pipeline regulatory framework were introduced to the South Australian parliament in September 2022 to facilitate better access to pipelines, provide more support for commercial negotiations between shippers and service providers, and streamline governance arrangements.

[14] Under the Australian Energy Market Agreement, national energy legislation is made in the South Australian parliament following agreement by energy ministers. Other states and territories have legislation to apply the South Australian laws in their own jurisdictions.

Table 9.1 Gas transmission lines and regulation (excluding Western Australia) in Australia

Transmission pipeline	Owner	State	Regulation
Amadeus Pipeline	APA	Northern Territory	Fully regulated
Central Ranges Pipeline	APA	New South Wales	Fully regulated
Roma Brisbane Pipeline	APA	Queensland	Fully regulated
Victorian Transmission System	APA	Victoria	Fully regulated
Carpentaria Pipeline	APA	Queensland	Lightly regulated
Central West Pipeline	APA	New South Wales	Lightly regulated
Moomba Sydney Pipeline	APA	New South Wales	Lightly regulated
Eastern Gas Pipeline	Jemena	New South Wales/Victoria	Not regulated
Queensland Gas Pipeline	Jemena	Queensland	Not regulated
Moomba Adelaide Pipeline	Epic	South Australia	Not regulated
Northern Gas Pipeline	Jemena	Northern Territory	Not regulated
South East Pipeline	Epic	South Australia	Not regulated
Berwyndale Wallumbilla Pipeline	APA	Queensland	Not regulated
Bonaparte Gas Pipeline	APA	Northern Territory	Not regulated
SEA Gas Pipeline	APA	Victoria/South Australia	Not regulated
South West Queensland Pipeline	APA	Queensland	Not regulated
Tasmanian Gas Pipeline	TGP Pty Ltd	Tasmania	Not regulated

Source: AER, (2022a).

Storage

Australia has several commercial gas storage facilities, mostly located on the east coast. Total gas storage capacity amounts to 300.7 PJ, or 8.5 bcm, which covers 20% of domestic demand. Located in Victoria, the Iona (26 PJ) and Dandenong LNG (0.7 PJ) facilities provide third-party access.

There has been a growing reliance in recent years on gas storage in the south-east to meet peak demand in the winter, with a particular reliance on the Iona facility, owned by Lochard Energy. In advance of the winters of 2021 and 2022, storage levels at Iona fell to their lowest point since reporting commenced. These low storage levels were further exacerbated by the gas supply crisis, when flows into the storage did not meet the significant increase in gas generation demand that occurred in the winter of 2022. In August 2022, energy ministers approved an urgent rule change to give the AEMO power

to contract underused storage capacity in Victoria before winter 2023. Lochard Energy is also engaged in a project to increase the Iona facility's flow rate.

Key gas storage facilities in Western Australia include the Mondarra Gas Storage and Processing Facility and the relatively new Tubridgi Gas Storage facility, which began commercial operations in September 2017. Once operational, the project is expected to produce gas for the domestic market for around two years before converting to an underground gas storage facility.

Table 9.2 Gas storage facilities in Australia

Storage facility	Operator	State	Capacity (PJ)
Roma	Gladstone LNG	Queensland	70
Silver Springs	AGL	Queensland	35
Ballera	Santos	Queensland	10
Iona	Lochard Energy	Victoria	26
Dandenong	APA	Victoria	0.7
Newstead	Origon Energy	New South Wales	2
Mondarra	APA	Western Australia	15
Tubridgi	Australian Gas Infrastructure Group	Western Australia	57
Moomba	Santos	South Australia	85
Total			**300.7**

Note: PJ = petajoule.
Source: DCCEEW, (2022).

LNG terminals

There are ten LNG export terminals in Australia; five in Western Australia (Wheatstone, Gorgon, Pluto, North West Shelf, Prelude), three in Queensland (Australia Pacific, Queensland Curtis, Gladstone) and two in the Northern Territory (Ichthys, Darwin). Total LNG export capacity is almost 120 bcm/year. The vast majority of export capacity at Australia's LNG terminals is booked under long-term contracts to buyers in Asian markets.

Outside Pluto LNG T2, there is no new LNG development. In the coming years up to 2023-2024, both the United States and Qatar will see higher levels of investment and will surpass any additional LNG from Australia (IEA, 2022b).

There are currently no LNG import regasification terminals in Australia, but several projects have been under consideration in recent years. The 2021 National Gas Infrastructure Plan highlighted a potential need for LNG import infrastructure in the south-east to enhance the security of gas supply. LNG import terminals in the south-east could be used both to import LNG from international markets as well as to receive domestically produced LNG from Western Australia.

Table 9.3 Constructed and planned liquefied natural gas projects in Australia

Project name	Major participants	State	Capacity (bcm/year)	Status
QCLNG (T1-T2)	BG Group	Queensland	11.6	Operational
APLNG (T1-T2)	Origin Energy, ConocoPhillips, Sinopec	Queensland	11.2	Operational
Darwin		Northern Territory	5.0	Operational
GLNG (T1-T2)	Santos, Petronas, Total, KOGAS	Queensland	10.6	Operational
Gorgon LNG (T1-T3)	Chevron, ExxonMobil, Shell	Western Australia	21.2	Operational
North West Shelf	Woodside	Western Australia	23.0	Operational
Pluto T1	Woodside, Tokyo Gas, Kansai Electric	Western Australia	6.7	Operational
Pluto T2	Woodside, Tokyo Gas, Kansai Electric	Western Australia	6.7	Planned
Wheatstone LNG (T1-T2)	Chevron, KUFPEC, Woodside	Western Australia	12.2	Operational
Prelude	Shell	Western Australia	4.9	Operational
Ichthys LNG (T1-T2)	Inpex, Total	Northern Territory	12.1	Operational
TOTAL			**125.1**	

Note: bcm = billion cubic metres.

Source: Australian Government Department of Industry, (2022) Global Resources Strategy commodity report: liquefied natural gas.

The most advanced LNG import project is the Port Kembla Gas Terminal (PKGT) in New South Wales being developed by Australian Industrial Energy (part of Squadron Energy). The PKGT is part of the wider Port Kembla Energy Hub project, which received AUD 30 million in funding from the Australian Government and was declared a “Critical State Significant Infrastructure” by the New South Wales Government in August 2021. However, the construction of the PKGT has been beset by delays with reports of reluctance on the part of gas customers to enter into supply contracts, which are needed to underpin the project. The PKGT was due to be completed in 2022 but is now not expected to be operational until 2024 at the earliest.

A number of other LNG import terminal projects remain in the early stages of development, including Venice Energy’s proposed terminal at Port Adelaide and Viva Energy’s Geelong Gas Terminal project. In the past, many projects have been delayed due to planning, environmental and other challenges. For example, plans for a proposed LNG import terminal at Crib Point were abandoned by AGL in May 2021 after the Victoria State Government rejected the project on environmental grounds.

Gas market structure and prices

In Australia's east coast gas market, the AEMO operates the wholesale trading markets, gas supply hubs and a supporting Gas Bulletin Board. In Western Australia, there is no spot market; all wholesale sales are made under bilateral contracts.

Wholesale market and trading in the east coast gas market

The wholesale east coast gas market is highly concentrated; the three major east-coast LNG producers (Australia Pacific LNG, Gladstone LNG and Queensland Curtis LNG) and their affiliates, which together accounted for around 80% of production in 2021, dominate wholesale supply.

The Australian Competition and Consumer Commission has consistently expressed concern in recent years about the high level of concentration in the supply of gas to the east coast market, as well as a lack of price transparency.

In the east coast gas market, around 80-90% of wholesale gas purchases are made by retailers and large industrial consumers under confidential bilateral contracts from the major east coast gas producers. Domestic and export volumes are sourced from the same assets and producers; exports are largely under long-term contract provisions.

Around 10-20% of wholesale sales in the east coast gas market are made via trading markets operated by the AEMO: Victoria's declared wholesale gas market (DWGM), the short-term trading markets, and the gas supply hubs at Wallumbilla in Queensland and Moomba, in South Australia.

To facilitate shorter term trading, the AEMO operates:

- gas trading hubs at Moomba and Wallumbilla
- short-term trading markets for gas at the city gates of Sydney, Brisbane and Adelaide
- a pipeline capacity trading platform
- a day-ahead auction for contracted but unnominated capacity
- a gas market Bulletin Board.

Victoria's declared wholesale gas market

Participants in Victoria's DWGM can submit daily bids ranging from 0 AUD/GJ (the floor price) to 800 AUD/GJ (the price cap). Prices in Victoria's DWGM cover gas as well as transmission pipeline delivery. The AEMO operates the financial settlements on the DWGM and manages the physical balance. Liquidity in Victoria's DWGM has been improving, with a continuous rise in trading volumes since 2019. Around 40 entities participated in the market in 2021.

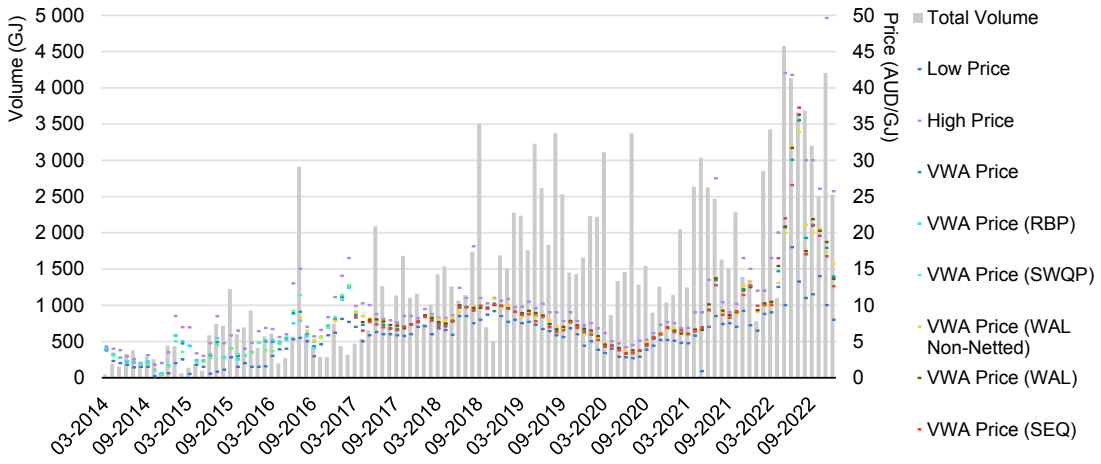
Short-term trading market

The short-term trading market allows trading on a day-ahead basis at three defined gas hubs in Sydney, Adelaide and Brisbane. The AEMO sets the day-ahead price at each hub with a price floor of 0 AUD/GJ and a cap of 400 AUD/GJ. Pipeline operators schedule flows to supply the necessary quantities of gas to each hub. The AEMO operates a balancing service – called market operator services – to meet any variations in gas deliveries or withdrawals from the schedule.

Gas supply hubs

Gas supply hubs at Wallumbilla in Queensland and Moomba in South Australia offer gas trading on a balance of day, daily, day-ahead, weekly and monthly basis. Participants can trade gas up to a year in advance of physical supply. Both the Wallumbilla and Moomba hubs are situated at major pipeline junctions. The AER monitors the hubs, reporting weekly on the level of activity at the Wallumbilla and Moomba supply hubs. In 2021, 17 participants traded at the gas supply hubs, mainly the LNG exporters and producers. In 2022, volumes of trade increased substantially at Wallumbilla. Gas traded on the supply hubs still represents only a small proportion of total gas sales. For example, in 2021, gas traded through the Wallumbilla hub accounted for just 9% of total gas flows through pipelines in the Wallumbilla bulletin board zone, while trade at the Moomba hub remained minimal. In general, most market participants prefer negotiating confidential, bilateral agreements.

Figure 9.7 Wallumbilla Gas Supply Hub – trade volume and volume-weighted average prices by pipeline



Notes: GJ = gigajoule; AUD = Australian dollar; VWA = volume-weighted average; RBP = Roma Brisbane Pipeline; SWQP = South West Queensland Pipeline; WAL = Wallumbilla; SEQ = South East Queensland trading location.
Source: AER, (2022b).

Gas Bulletin Board

To improve transparency in the east coast gas market, the AEMO established the Gas Bulletin Board in 2008. The Gas Bulletin Board is an electronic platform that provides up-to-date information on gas production, storage, transmission pipeline capacity and flow in the east coast gas market. Pipeline operators, gas producers and storage facility owners must submit information to the AEMO, and the AER monitors participants' compliance.

Wholesale market in Western Australia

In Western Australia, the vast majority of gas is supplied directly through the transmission network, with a small minority being supplied on a retail market through distribution networks. In most of the gas supply transactions, gas producers sell ex-plant to large industrial customers, who arrange their own gas transport agreements with the relevant pipeline operators. Unlike the eastern market, there is no short-term gas trading market in Western Australia. The Western Australia wholesale market also includes a Gas Bulletin Board, operated by the AEMO, showing information on gas production, consumption and

capacity outlooks. The geographically separate Western Australian Gas Market is serviced by four major natural gas transmission pipelines (all of which are interconnected) and several smaller pipelines. The market has a gas reservation policy, requiring producers to "reserve" 15% of their production for the domestic market.

Wholesale gas market reforms

In June 2022, a package of gas market transparency measures was passed by the South Australian parliament, which will provide gas market participants under the national gas regulatory framework with better information on gas, LNG and infrastructure prices; the supply and availability of gas; and where uncontracted supply or infrastructure capacity is available. These reforms are automatically adopted by other states in the NEM under the National Gas Law and National Gas Rules, creating a cohesive set of state reforms. This new framework will support gas market participants' contractual negotiations and investment decisions and commence operation in the coming months.

In August 2022, state, territory and Commonwealth energy ministers agreed to progress reforms to improve the flexibility and liquidity of domestic gas markets. The reforms will include harmonising arrangements across the three spot markets to reduce trading costs for participants who trade across markets. They also enable trades through the Wallumbilla Gas Supply Hub to be automated and fully anonymised, encouraging more on-screen trades.

Retail market

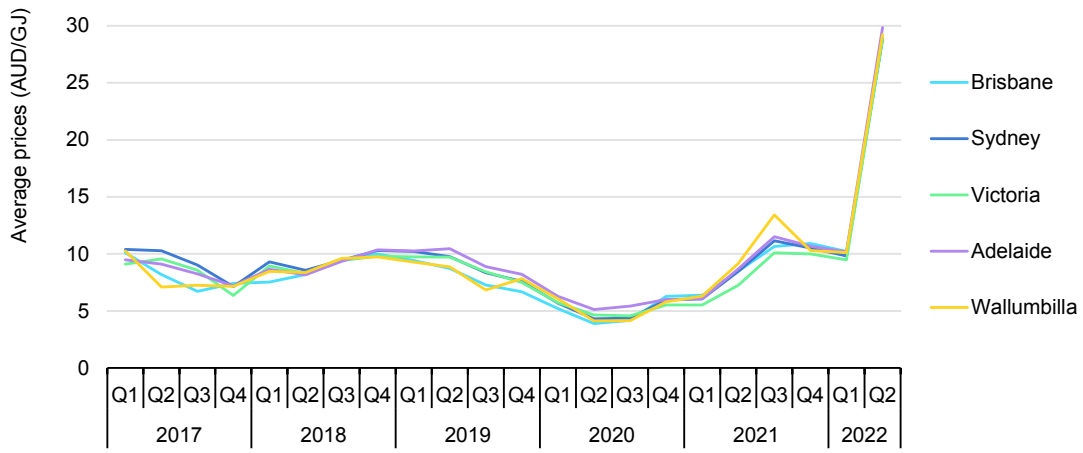
The retail gas market on the east coast is also highly concentrated. In 2020, there were 18 retailers operating in total, of which 16 operate in New South Wales, eight in Queensland, ten in South Australia and four in the Australian Capital Territory. However, three companies designated as "Tier 1" retailers by the AER – AGL, EnergyAustralia and Origin Energy – accounted for a combined market share of almost 90% of supply to residential consumers in New South Wales, South Australia and south-east Queensland. However, the market share of Tier 2 retailers has been increasing.

Prices and taxation

There is a significant lack of price transparency in Australia's gas market due to the high prevalence of confidential bilateral contracts. The ACCC collects some gas contract information and reports on these prices through its Gas Inquiry. The ACCC began publishing the LNG netback price series in 2018 in an attempt to provide more transparent benchmarks for how domestic and international prices compare. The LNG netback price represents the price at Wallumbila that a gas supplier would expect to receive for gas if it was converted to LNG and exported.

From May to June 2022, gas spot prices skyrocketed in the east coast market, reaching record highs. This prompted the AEMO to impose a price cap on spot markets in June 2022 as cumulative price thresholds were breached. Spot prices moderated in August 2022 but remain elevated from past years' levels. The ACCC has noted concern that these prices will have implications for future contract prices. According to AEMO price reports, the average August 2022 price in Wallumbilla fell back to 16 AUD/GJ (similar to the price in April), down from 41 AUD/GJ in July 2022 but still higher than in past years (AEMO, 2022a).

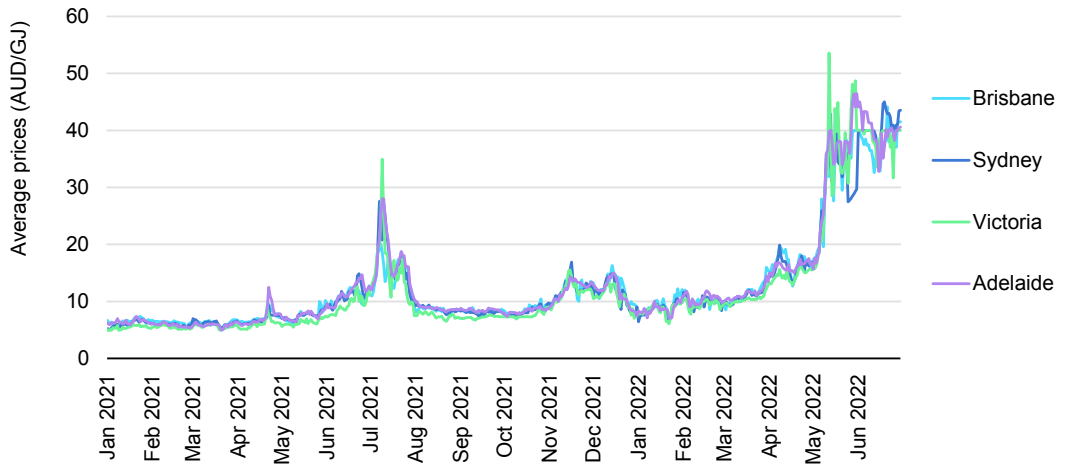
Figure 9.8 Eastern Australia gas market prices, 2017-2022



Note: AUD/GJ = Australian dollar per gigajoule.
Source: AER, (2022a).

The ACCC and the AER collect some retail price data, but there is no regular publication of retail prices. Retail gas prices are subject to market forces and are not fixed by most jurisdictions or a regulatory body. Western Australia is the only jurisdiction that annually sets a cap on retail prices for small customers. The Australian Government is engaged in ongoing consultations regarding improvements to price transparency and data availability.

Figure 9.9 Eastern Australia daily gas spot prices, January 2021 – June 2022



Note: AUD/GJ = Australian dollar per gigajoule.
Source: AER, (2022a).

Special focus: The role of gas in Australia's energy transition

As a leading exporter, Australian LNG serves an increasingly tight global gas market and is a source of global supply flexibility, including in Asia, notably in the context of Russia's invasion of Ukraine and the significant cut of Russian gas supplies to Europe.

Domestic gas consumption in Australia has been stable in the recent five years with a solid role in power generation as flexibility source and strong growth in mining and LNG production. The Climate Change Act 2022 sets strong decarbonisation targets for the Australian economy up to 2030 and 2050 and gas demand is forecast to slowly decline. Alternative supply sources such as hydrogen and renewable gases are actively being developed in Australia.

There is considerable uncertainty for investment in natural gas production and related infrastructure, which reduces the private sector's willingness to maintain existing infrastructure assets and invest in new capacity. In this decade, however, supply/demand imbalances and shortages in both domestic and international markets may result in significant price volatility and questions around the reliability of supply, notably in Asia. The key question for Australia's domestic energy system is how to maintain investment in critical energy infrastructure and the role of hydrogen and renewable gases. At the same time, the pace of Europe's and Asia's energy transitions will also determine Australia's gas investment outlook, which has a wide range of possible trajectories for global LNG demand.

Investment in natural gas production and gas infrastructure

Global investment in gas and LNG has been subdued for several years, with a large drop in 2020 due to the Covid-19 pandemic. No new LNG investment is expected to come to the global market before 2025. However, global gas demand has recovered from Covid-19 in 2021, and as a result of Russia's invasion of Ukraine, the global gas market, and Europe's in particular, will need to find additional gas supply to replace Russian gas by drawing on 40 bcm of LNG in 2023. This has increased the call on LNG producers such as Australia, Qatar and the United States to step in. Australia has been less able to increase its exports in the current environment, as its production cannot be ramped up quickly - resource development in Western Australia and the Northern Territories is time- and cost-intensive. Only one LNG liquefaction project is being planned.

In the medium term, the IEA *World Energy Outlook 2022* confirms that the golden age of gas will draw to an end by 2030 (IEA, 2022c). There is only a limited window for investment to scale up LNG production by 2025-30. This will largely depend on the gas supply outlook in developing Asia. For the global energy sector, the IEA *Net Zero Roadmap 2021* underlined that investment in existing mature fields is compatible with the net zero emissions by 2050 pathway (IEA, 2021). While the IEA roadmap applies to the global energy economy, the outlook will be different in every country.

Domestically, the outlook for natural gas demand and supply in Australia remains uncertain up to 2027-2030. On the demand side, south-east coast domestic gas demand is expected to decline, but gas demand is expected to persist in the power sector to replace retiring and inefficient old coal plants, according to the AEMO's Gas Statement of Opportunities 2022. Total consumption is forecast to fall in all scenarios as consumers switch from natural gas to lower or zero emissions alternatives, including electricity and hydrogen. This also sets the pace for deploying alternative fuels and related infrastructure.

In power generation, natural gas is expected to continue to play a role as a key source of dispatchable electricity supply as the penetration of variable renewable energy generation grows. Gas in power generation will likely serve peak electricity demand periods or when variable renewable generation is insufficient ("doldrums"), particularly during the winter.

In the south, gas is a major feedstock for manufacturing industries and the heating sector. Long-term uncertainty around the future of gas consumption is the greatest in the industrial sector and in heat generation, where there is substantial potential for the displacement of natural gas.

Some states and territories are looking at a future where gas does not play a major role. This includes the Australian Capital Territory Powering Canberra plan and the Victoria Gas Substitution Roadmap.

A combined increased international and domestic call on natural gas could result in higher prices in Australia and a supply deficit, as experienced in 2022. No new gas fields have come online for the domestic market, and most fields are in fast decline. The National Gas Infrastructure Plan of 2021, however, confirmed the potential development of several onshore gas projects as a means of enhancing the security of gas supply in the domestic market.

More robust policies are needed to improve the liquidity, competition and availability of natural gas supply in Australia alongside gas supply security measures. This involves greater resilience of gas infrastructure and maximising gas supply for the domestic market; the use of strategic reserves of natural gas, notably for the power sector; combined with demand-side measures, notably energy efficiency to alleviate price pressure; alongside the increase in renewable gases and hydrogen. Natural gas availability needs to be more flexible with higher ramping capabilities from storage, LNG import terminals and greater co-ordination of gas and electricity markets.

Scaling up hydrogen and renewable gases in the gas network

A package of domestic gas and electricity market reforms is needed to ensure investment in the transition to low-emission gases, notably hydrogen, biomethane or renewable gases, and related repurposing of natural gas infrastructure. The Australian Government is now on the way to undertake such reforms, which are already in place in Europe (see Box 9.1).

Around nine blending projects are expected to be operational by 2025 (DISER, 2021). Based on the experience gained from the demonstration projects, the government is reviewing legal frameworks affecting the hydrogen industry at Commonwealth and state levels.

The Australian Government is reviewing the hydrogen regulatory framework. At their 28 October 2022 meeting, energy ministers agreed on a legislative approach to extend the national gas regulatory framework to hydrogen, biomethane and other renewable gases. As a part of the National Hydrogen Strategy, energy ministers are also undertaking work to understand the economics of hydrogen blending and 100% hydrogen use and safe upper limits of hydrogen blending in domestic gas networks.

Once the pipelines access and renewable gas reforms are passed by the parliament of South Australia, all new covered gas pipelines, including hydrogen, will be subject to a “light-handed” access regime. New pipelines may apply for a greenfield incentive – exemption from a stronger form of regulation for up to 15 years and price protection – through an arbitration process. The government is adopting “ring-fencing” provisions on pipeline service providers (a focus on vertical separation) and consumer protection measures. This is strongly inspired by the principles of the new EU regulatory regime.

However, Australia has not decided in favour of stricter unbundling rules or the transition to a fully regulated access regime after 2030.

Box 9.1 The European Union hydrogen and decarbonised gas market package: An example for Australia to consider

The EU hydrogen and decarbonised gas market package provides an example for Australia to consider as it attempts to create the conditions to facilitate scaling up hydrogen and renewable gases in its domestic gas network.

The European Union is implementing reforms (presented in 2021 and adopted in 2022) to support the shift from natural gas to low emissions gases, notably biomethane and hydrogen, and strengthen the resilience of the gas system. The European Union is working on a gradual approach to create a market for hydrogen by 2030, with dedicated infrastructure, trade with third countries, access rules to hydrogen infrastructures, separation of hydrogen production and transport activities, and tariff setting. System operation and grid codes for the future EU hydrogen market are to be overseen by a new European Network of Network Operators for Hydrogen. National network plans must be based on a joint scenario for electricity, gas and hydrogen, aligned with national energy and climate goals and the EU-wide Ten-Year Network Development Plan.

Up to 2030, the new rules will enable low emissions gases to access the existing gas grid (by removing cross-border tariffs and lowering injection tariffs) based on a certification system for low emissions gases. Consumers will be able to choose low emissions gases; switch gas suppliers more easily; use effective price comparison tools; get accurate, fair and transparent billing information; and access data and new smart technology.

Gas security rules are also extended to include low-emission gases, taking a more strategic approach to gas storage, integrating storage into regional risk assessments and voluntary joint procurement of strategic stocks by European Union member states, in line with the EU competition rules.

The European Union is also establishing a first-ever methane regulatory framework, covering the oil, gas and coal sectors, including standards for measuring, reporting and verifying methane emissions. The rules require companies to measure and quantify their asset-level methane emissions at source and conduct comprehensive surveys to detect and repair methane leaks in their operations. In addition, the proposal bans venting and flaring practices.

Under REPowerEU, hydrogen deployment in the European Union is being accelerated with a target of 10 MT of domestic hydrogen production and 30 MT of imported renewable hydrogen by 2030. The newly created European Hydrogen Bank will invest EUR 3 billion to connect hydrogen supply and demand during the scale-up phase to enable a renewable hydrogen market and trade across and with the EU.

There are concerns that gas suppliers still dominate the infrastructure ownership as unbundling has been incomplete. Most gas transport companies are still part of a vertically integrated company. As Australia needs to ensure that different sources of gas (biomethane and hydrogen) have access to gas infrastructure, greater enforcement of third-party access and monitoring competition will be critical to ensure a level playing field for companies in a changing energy and gas market.

As for the production of natural gas, the production of low emissions, renewable or low emissions sources of gas could be competitive activities, so transporting these new gases may require regulatory oversight (feed-in rules, third-party access rules) and tariffs to create a level playing field.

With the emergence of new technologies, notably energy storage such as hydrogen, the APA monopoly on the identification of system needs may be problematic, and infrastructure planning should be carefully revisited to also allow for sector coupling and ensure network planning and investment decision making are not foreclosing investment by other new market players in the area of low emissions gas production and transport.

The revision of the gas market rules should include the classification of low emissions gases (life cycle emissions, certification and standards, and methane emissions) to facilitate efforts to identify and support priority projects based on criteria adapted to new sources of gas. The AEMO's ISP could be a starting point for this (AEMO, 2022c).

In 2023, energy ministers will adopt new rules based on the recommendations from the AEMC with regard to necessary amendments to the National Gas Law and National Energy Retail Law.

Security of supply in the east coast gas market

There are significant and growing concerns about the security of gas supply to the domestic market, particularly to the most populated south-eastern regions. Most of the gas produced is committed to long-term LNG export contracts, and as domestic gas production is in decline, there is limited flexibility for uncontracted gas to satisfy the incremental or peak demand in the domestic market.

In June 2022, considerable tightness in the eastern Australian gas market was caused by a confluence of factors: a period of abnormally low temperatures resulted in a strong increase in power and heating demand, and technical failures at several coal-fired plants exacerbated the spike in gas demand for electricity generation. These events occurred as global LNG export demand, and thus the call on Australian LNG, rose to record levels and global gas prices soared following Russia's invasion of Ukraine.

As a result of sharply rising wholesale prices and reports from market participants that supply was insufficient to meet demand in the east coast market, the AEMO intervened to enforce a temporary price cap of 40 AUD/GJ in the Sydney and Brisbane short-term trading markets as well as in the Victorian gas market, as cumulative price thresholds were breached and retailer of last resort provisions were triggered with the failure of a retailer (Weston Energy). The AEMO also triggered the Gas Supply Guarantee, facilitating additional gas flows from the north to the south to meet gas generation demands.

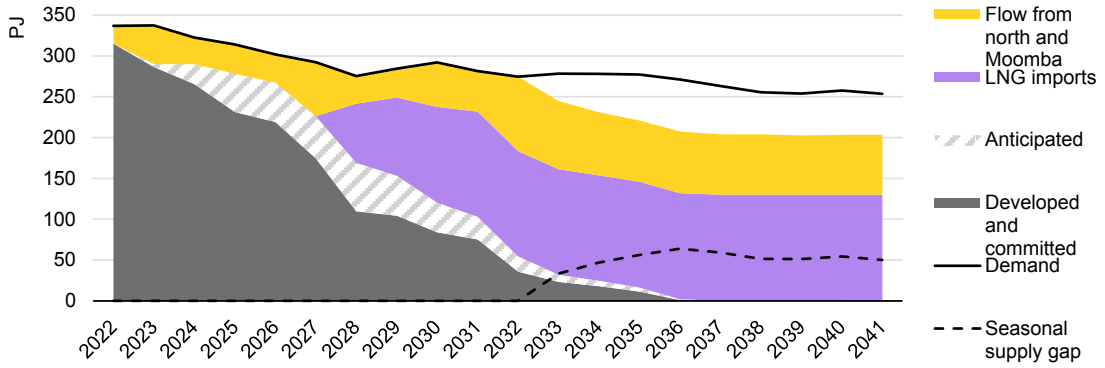
The AEMO's actions provided temporary market relief and resulted in increasing gas flows from Queensland to the south-eastern states. However, while a deeper crisis was averted,

the situation has highlighted the considerable vulnerability in Australia's east coast gas market, as well as the potential need for enhanced emergency preparedness.

Forecasts from the ACCC and the AEMO have flagged the risk of significant gas shortfalls in the winter of 2023, particularly if gas demand rises sharply as a result of extreme weather or capacity outages at coal-fired power plants. In such a case, supply to the south-east, where there is currently no LNG import capacity, could be constrained by insufficient pipeline and storage capacity. There are also medium-term risks to the security of gas supply related to the ongoing decline of production in fields which have traditionally supplied the south-eastern regions, such as those in the Bass Strait (off the coast of Victoria).

The AEMO's Gas Statement of Opportunities (AEMO, 2022b) forecasts an adequacy gap from 2032 onwards, as domestic production is declining fast while demand is coming from power generation. The AEMO builds its analysis on redirecting LNG exports to the domestic market (through the Heads of Agreement).

Figure 9.10 Projected annual adequacy in south-eastern regions in Australia, Step Change Scenario, 2022-2041



Notes: PJ = petajoule; LNG = liquefied natural gas.
Source: AEMO, (2022b).

Concern about the security of supply to gas markets in the south-eastern regions has grown at the same time as Australia's LNG exports have risen significantly. The Government of Western Australia obliges gas producers operating in its jurisdiction to reserve around 15% of production for the domestic market. Queensland's Australian Market Supply Condition is the only current arrangement in the eastern states. Under normal circumstances, the major LNG producers in Queensland are under no obligation to supply the local market and are free to export the totality of their production. In 2021, Queensland producers exported their production in the form of LNG, mostly under long-term contracts. The remaining volumes not exported under long-term contracts were sold on Asian LNG spot markets.

Australian Domestic Gas Security Mechanism

In response to concerns about the security of gas supply in the south-eastern regions, the Australian Government introduced the Australian Domestic Gas Security Mechanism (ADGSM) in 2017. It could theoretically be used to restrict LNG exports from the east coast in the event of a domestic shortfall.

Under the ADGSM, the government can control LNG exports if it is determined that a market shortfall will develop in the following calendar year. The ADGSM has never been activated. However, the actual implementation of the ADGSM has been considered as impractical, not least because it takes a significant amount of time to implement as a result of the extent of the consultations required before it can be used. It is also unclear how great the supply shortfall would need to be to trigger the ADGSM, the lack of a link between the forecast shortfall volume and the volume of gas to be recovered, and how the size of the supply shortfall would be calculated. In addition, successive governments have shown reluctance to consider the implementation of the ADGSM due to the potential negative signal it could send regarding the reliability of Australian LNG supply to trade and investment partners.

The ADGSM was due to expire in January 2023, but in August 2022, the government announced it would retain the mechanism until 2030. In October 2022, the government announced reforms to the ADGSM. As part of these reforms, the Minister for Resources will receive expert advice quarterly on whether market conditions merit the activation of the ADGSM; previously this was reviewed once per year. The government plans to announce the detailed design of the reformed ADGSM by mid-2023.

Heads of Agreement

As well as holding the potential last resort of activating the ADGSM, the government has also sought to guarantee supply to the south-eastern regions by seeking the voluntary co-operation of LNG exporters. The government signed an updated Heads of Agreement (non-binding letter of intent) with the major east coast LNG producers in 2021 (updated from previous agreements in 2017, 2018 and 2020), in which the LNG producers agreed to offer uncontracted gas to the domestic market on internationally competitive terms before offering it to the international market.

However, stakeholders have noted concerns about compliance with the Heads of Agreement, particularly relating to the price and impractically large volumes at which uncontracted gas has been offered to the domestic market.

As a result of recent tightness in the Australian gas market, the government renegotiated the Heads of Agreement. On 29 September 2022, the Minister for Resources signed a new agreement with Australia Pacific LNG, QGC Pty Ltd (operator of Queensland Curtis LNG) and Gladstone LNG. The new commitments from LNG exporters will lead to an extra 157 PJ being offered to the domestic market in 2023, with the gas to be supplied in line with seasonal demand. The new Heads of Agreement includes:

- LNG exporters to first offer uncontracted gas to the domestic market at prices that ensure that domestic gas customers will not pay more than international customers on terms consistent with a code of conduct (Voluntary Code of Conduct for the Negotiation and Development of Gas Supply Agreements between Gas Suppliers and Gas Customers in Australia).

- Enhanced transparency and accountability measures, with quarterly compliance reporting to the Minister for Resources and annual delivery plans, with oversight by the ACCC, based on definitions of key terms, such as “competitive market terms”, “uncontracted gas”, “reasonable notice” and “supply term”.
- Minimum standards relating to gas supply agreements, pricing principles, appointment of a code arbiter, referring to the LNG netback price as a benchmark price.

Gas Supply Guarantee

The Gas Supply Guarantee is an informal, non-binding mechanism under which gas producers and pipeline service providers make voluntary commitments to prioritise gas supply to gas-powered generators under certain peak demand/supply shortfall conditions. Under the mechanism, if the AEMO identifies a risk of potential supply shortfall over a three- to four-day period, it can call a conference with the relevant market participants to resolve the issue. In November 2021, the AEMO published a review of the mechanism and advised that it remain in place until at least March 2026. The Gas Supply Guarantee was triggered for the first time in June 2022.

On 12 August 2022, the Commonwealth, state and territory energy ministers agreed to a series of gas market reforms for the east coast gas market. As a first step, the AEMO’s functions and powers will be strengthened with regard to the management of reliability and supply adequacy risks across the east coast gas market in the winter of 2023. These reforms will allow the AEMO to: better monitor and forecast potential shortfalls; notify the market of emerging risks and seek market responses to address the threat; use direction powers as a last resort where the market cannot or does not respond; and recover costs to support the implementation of the reforms. Energy ministers agreed on amendments to the National Gas Law on 28 October 2022, and the amendments will enter a South Australian parliamentary process with the aim of having the changes in place by April 2023. Initial rules will be made once the bill has been passed.

The second stage of reforms will be undertaken in 2023. This stage will include consultation on the merits of additional reliability and supply adequacy measures. This could include: an east coast gas market reliability standard, a Reliability and Emergency Reserve Trader framework, and a potential reliability obligation on retailers and gas power generators.

Gas emergency policy and response

As specified in the National Gas Law, responsibility for natural gas emergency response lies with the eight state and territory governments. All state and territory governments have their own legislation pertaining to gas emergencies. The federal government does not have any direct emergency powers.

In the state of Victoria, the largest gas-consuming state, the AEMO, a public-private partnership that manages electricity and gas systems and markets across Australia, has direct emergency powers. However, the AEMO currently does not have emergency powers outside Victoria; all other states and territories have separate emergency management agencies.

If a gas emergency affects two or more jurisdictions with an interconnected gas supply network, the crisis is co-ordinated by the National Gas Emergency Response Advisory

Committee. The role of the committee was reinforced in a 2016 memorandum of understanding between the Australian Government and all states and territories. The committee is chaired by a representative from the DCCEEW and supported by a permanent secretariat from the AEMO.

As specified in the National Gas Law, the AEMO has the power to suspend the gas spot markets and administer a price cap of AUD 40 per GJ under certain emergency circumstances. These circumstances include the collapse of a retailer of last resort, a cumulative price threshold being exceeded, and the technical failure of software related to the spot markets.

Box 9.2 Australia's 2022 gas supply emergency

In June 2022, a confluence of factors caused considerable tightness in the eastern Australian gas market: a period of abnormally low temperatures resulted in a strong increase in power and heating demand, and technical failures at several coal-fired plants exacerbated the spike in gas demand for electricity generation. These events occurred as global liquefied natural gas export demand, and thus the call on Australian LNG, rose to record levels and global gas prices soared following Russia's invasion of Ukraine.

As a result of sharply rising wholesale prices and reports from market participants that supply was insufficient to meet demand in the east coast market, the Australian Electricity Market Operator (AEMO) intervened to enforce a temporary price cap of AUD 40 AUD per GJ in the Sydney and Brisbane short-term trading markets as well in the Victorian gas market. The AEMO also triggered the Gas Supply Guarantee for the first time, facilitating additional gas flows from the north to the south to meet gas generation demands.

The AEMO's actions provided temporary market relief and resulted in increasing gas flows from Queensland to the south-eastern states. However, while a deeper crisis was averted, the situation has highlighted considerable vulnerability in Australia's east coast gas market, as well as the potential need for enhanced emergency preparedness.

Assessment

Australia is the seventh-largest producer of natural gas globally and is now the world's largest LNG exporter. In 2021, natural gas production stood at 156 bcm. Production has increased by almost 190% since 2010, driven by a rapid expansion of the Australian LNG industry on both the east and west coasts. Australia primarily exports gas to markets in Asia, with Japan as the most important export destination (40%), followed closely by China (39%) in 2020. Australia is supplying LNG to Asian markets under long-term contracts.

To make up for the fall-out of Russian gas supply in Europe and indirectly in Asia, the global LNG market is increasingly calling on Australia to match the supply shortfalls in the medium term. Exports stood at 103 bcm, which is 354% higher than in 2010. With Europe becoming a premium LNG market, Australian LNG is also making its way to Europe directly (six cargoes in 2022, or 0.5% of total Australian exports). In the coming years, Australia's gas production must meet domestic and export needs. Australia plays an important role

as a net exporter to the Indo-Pacific, today through LNG and eventually hydrogen exports to assist with the regional net zero transition. Today, 70% of natural gas production, or 100 bcm, is exported based on long-term contracts, leaving only 30% to satisfy domestic needs (40 bcm).

Australia's LNG export earnings are forecast to rise from an estimated AUD 70 billion in 2021-2022 to AUD 90 billion in 2022-2023, driven by rising global energy and commodity prices. This provided an incentive for many LNG facilities to operate at or above capacity. The Petroleum Resource Rent Tax Revenue also increased, from AUD 897 million in 2020-2021 to AUD 2.17 billion in 2021-2022. However, domestic gas prices in Australia have also been on the rise, which puts industry, commercial and household consumers under pressure. To mitigate these impacts, in December 2022, the Australian parliament passed legislation which introduces a price cap on domestic gas prices of AUD 12 per GJ for the temporary period of one year.

The adequacy gap is already becoming an issue, as in 2022 Australia experienced a double call on LNG from the international and domestic markets. In June 2022, increased demand and tight supply caused a spike in wholesale gas prices in the east coast market, resulting in a significant national debate about the security of gas supply and affordability of gas and the clean energy transition.

In the short term, there are a few gas production developments in Western Australia: the Scarborough gas project and the Crux offshore gas field to feed the existing Prelude FLNG facility, all destined for exports and not connected to the east coast market. The potential for developing new onshore gas production in the east Australian gas market is limited due to public opposition and several states issued *de facto* moratoria on new gas development. In June 2022, the Australian Government rejected a moratorium on all new fossil fuel development and confirmed that it intends to remain a producer in the coming years. However, there is no major investment in domestic production planned.

In Western Australia, 15% of LNG production must be reserved for domestic use, a strategy that has been successful in keeping gas prices low in the domestic market. No such policy exists in the east coast market, leaving it more exposed to global price dynamics. However, the government is commended for updating its agreement with LNG exporters who have committed to offer all uncommitted gas to the east coast in the coming years. In 2022, Australia concluded a new Heads of Agreement with the major LNG companies to commit all flexible gas (on top of long-term contracted gas) to the domestic market. This sets an important guarantee for Australian LNG to remain available as contracted, given the large supply gap anticipated around 2030. Despite the existence of this framework, it remains difficult to implement through a voluntary code and requires compliance checks and possible LNG export restrictions.

Australia needs to adopt a transition policy framework that puts the Australian market on the road to net zero emissions by 2050. Under a net zero pathway, investment in natural gas production and transport will decline strongly after 2040, as will demand for Australian LNG exports. Demand for low emissions gases will increase.

Gas production centres are largely geographically distant from demand centres. The West Coast Gas Market is not connected to east coast demand centres through a pipeline network. The eastern Australian gas market is serviced by an interconnected transmission

pipeline system – the East Coast Grid. The Northern Territory was connected to the East Coast Grid after the Northern Gas Pipeline commenced commercial operations in January 2019.

However, the east coast market also currently suffers from transmission capacity constraints, although some infrastructure owners have committed to upgrades. Australia's gas transmission sector is privately owned, with APA Group as the largest player. Stakeholders disagree on whether additional pipeline capacity or better capacity use would alleviate pressure on the domestic gas market during peak demand periods. In 2021, the National Gas Infrastructure Plan identified priority gas infrastructure developments for 20 years.

The National Gas Infrastructure Plan also outlined the need for increased gas production, expansion of gas storage and significant investment in pipeline infrastructure to the south.

Several gas market reforms have been made. A regulated framework for the trading of pipeline capacity commenced in 2019. The government has simplified and strengthened the access framework since 2017, when it directed the ACCC to conduct a wide-ranging inquiry into the supply of and demand for natural gas in Australia, as well as to publish regular information on the supply and pricing of gas, including semi-annual reports through 2030. The ACCC reporting has noted on several occasions that there is a need to increase the diversity of gas suppliers, particularly in the southern states of the east coast gas market. At the same time, it has also pointed out a lack of price transparency.

The progress in gas market reforms remains vital and should be prioritised to create a competitive gas market. The gas price cap, which was introduced in December 2022 at AUD 12 per GJ on new east coast gas supplies, should remain temporary and not become a remedy to deal with structural market shortcomings. Gas producers selling in the wholesale market above cap could face AUD 50 million or more in penalties. If it continues to apply for a sustained period of time, investment in natural gas production development can be at risk.

The government has worked on a number of reforms in the gas sector to increase transparency and competition and liquidity in east coast facilitated gas markets. The National Gas Infrastructure Plan identified priority pipelines and other critical gas infrastructure alongside reforms to further boost competition and transparency by reforming the regulations on pipeline infrastructure. The plan proposed a secondary pipeline capacity market. The introduction of a voluntary Code of Conduct for the gas industry is proposed with enhanced monitoring of prices.

Australia does not have significant underground gas storage, and most of it is located on the east coast. Most storage terminals do not offer third-party access; only the Dandenong and Iona storage facilities in the south-east provide storage services to third parties. The Dandenong LNG storage facility is used to store small volumes of gas to be injected for peak shaving purposes into the Victorian Transmission System. The Iona underground storage facility is usually used to store large volumes of gas during the summer months, which are withdrawn in the winter to meet peak and seasonal demand. Key gas storage facilities in Western Australia include the Mondarra Gas Storage and Processing Facility and the relatively new Tubridgi Gas Storage facility, which began commercial operations in September 2017. In August 2022, energy ministers agreed to investigate extending third-party access arrangements to upstream production infrastructure and storage facilities.

There are no LNG import terminals, but plans have been put forward to develop a number of import facilities in the southern states to resolve a forecast shortfall in gas supply. Some of the import facilities were intended to be operational from 2020, but many projects have been delayed by planning, environmental and economic challenges.

Given the strong links between the gas and electricity markets on the east coast of Australia going forward, there is a need to focus more on demand management in both markets, storage obligations, energy efficiency in industry and buildings (switch to heat pumps alongside appliance shift), as well as an accelerated deployment of solar and wind and dispatchable electricity generation (battery storage, bioenergy and flexibility products). An integrated planning regime that includes gas, like the AEMO's Integrated System Plan, is the best way to increase visibility for investment and planning of the gas and electricity systems. Energy ministers have agreed to explore this through the National Energy Transformation Partnership.

A framework for low emissions gases

Amid forecasted declining demand for natural gas in a net zero future, the Australian Government is examining the transition of incumbent gas infrastructure to either sunset or retrofit for future low emissions gases. Australia was an early adopter of blending renewable hydrogen into the natural gas network. The *State of Hydrogen 2021* report expected nine blending projects to be operational by 2025, with several projects already supplying low emissions gases to Australian homes. The projects benefit from federal and state government funding, partly via the Australian Government's AUD 1.2 billion co-investment facility.

Regarding the design of the national gas regulatory framework, Australia has referred to international examples in reforming the regulatory framework to allow for third-party access to infrastructure and the transport and blending of low emissions gases, including biomethane and hydrogen in gas networks.

First, the production and trade of low emissions gases require revising the energy market rules to include the classification of low emissions gases (life cycle emissions, certification and gas quality). Like the production of natural gas, producing low emissions gases could be a competitive activity.

Transporting these new gases may require regulatory oversight (feed-in rules, third-party access rules) and tariffs to create a level playing field. Experience in the European Union shows (Decarbonised Gas Package) that third-party access is required so that different sources of gas (biomethane and hydrogen) have access to gas infrastructure. In the October 2022 reform package, energy ministers have agreed to subject new pipelines to a third-party access regime with options for greenfield incentives and price protection determinations. Greater enforcement of third-party access and of competition will be critical to ensure a level playing field for companies in a changing energy and gas market.

With the emergence of new technologies, notably energy storage options such as hydrogen, the monopoly of transmission and distribution network companies in identifying energy system needs may be problematic. Infrastructure planning should be carefully revisited to also allow for sector coupling and ensure transmission/distribution network planning and investment decision making is not foreclosing investment by other new market players. The AEMO's Integrated System Plan can play an important role in this regard.

In 2022, the AEMC recommended rules to energy ministers to change the national gas and retail regulatory frameworks so that low-level hydrogen gas blends and renewable gases can be safely supplied through existing distribution pipelines to appliances in homes and businesses.

Recommendations

The government of Australia should:

- ☐ Ensure full implementation of the Heads of Agreement and support its future review and renewal.
- ☐ Create a national road map for the role of gas in Australia's transition, in consultation with industry and consumers, with concrete milestones on the road to net zero emissions by 2050 and an outlook for the transition to low emissions gases.
- ☐ Continue to pursue measures in the gas market to increase competition and transparency, such as anonymous trading, third-party access and wholesale market integrity.
- ☐ Consider the lifetime of new gas infrastructure and ensure it enables the transition to a low emissions gas transition through the approval, certification and permitting processes.
- ☐ Implement and monitor the effectiveness of reforms to the National Gas Law that include low emissions gases and ensure the National Gas Objective aligns emissions reduction goals with security, competition and affordability objectives. Ensure that any new natural and low emissions gas production meets high environmental and community standards for both domestic and international markets to support the global energy transition.
- ☐ Urgently review the need for additional gas storage capacity, including the benefits to consumers in the energy transition, and whether sufficient incentives exist or need to be put in place for the construction of additional storage.
- ☐ Ensure co-ordinated infrastructure planning and investment outlooks of the power and gas sectors and demand-side management.

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10. Oil

Key data

(2021)

Crude oil production: 440 kb/d

Net exports of crude oil*: 32.3 kb/d (total imports 112.2 kb/d, total exports 128.2 kb/d)

Domestic production of oil products: 333 kb/d, -51% since 2011

Net imports of oil products: 530 kb/d, +115% since 2011

Share of oil: 52% of TFC, 32% of TES**, 4% of domestic energy production and 1.8% of electricity generation

Oil consumption (2020): 892.3 kb/d (domestic transport 65.4%, industry including non-energy consumption 22.4%, international bunkering 9.1%, buildings 2.4%, electricity and heat generation 0.4%)

* "Imports/exports of crude oil" includes crude oil, natural gas liquids and feedstock.

** Total energy supply does not include oil used for international bunkering.

Overview

The share of oil in TFC in Australia has remained relatively stable since 2000 at around 50%; in 2021, oil constituted 52% of TFC (Figure 10.1). The share of oil in TES was 32%.

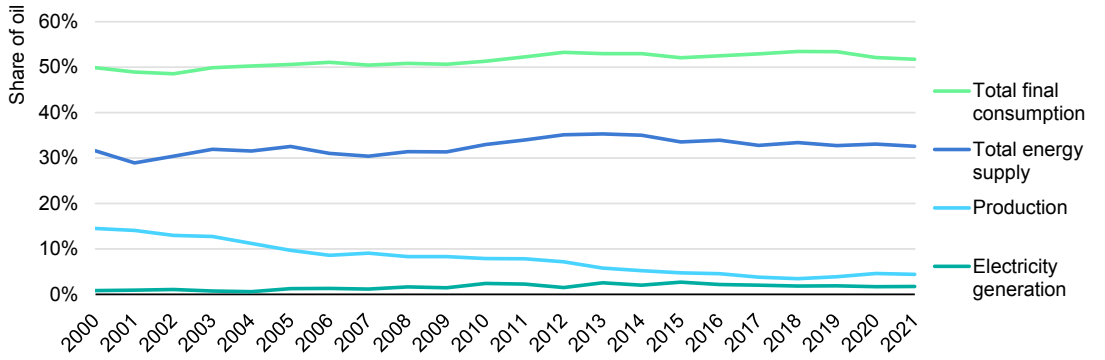
Australia has a sizeable upstream oil industry, and the country was a small net exporter of crude oil in 2021. Remaining conventional oil reserves equate to about 14 years of current production.

Domestic oil products production declined significantly due to a very large amount of refining capacity rationalisation in the past decade. As a result, Australia has become increasingly reliant on imports to meet oil product demand. Before declining as a result of the impacts of the Covid-19 pandemic since 2020, oil product demand had been on an upward trajectory since the mid-2000s, with particularly strong growth in diesel consumption. The government expects oil consumption to grow in the near term and persist into the 2030s.

The Australian Government developed a number of measures relating to the security of oil supply as part of the 2020-2021 and 2021-2022 Budgets. These measures focus on supporting investments in oil storage and providing incentives to ensure that Australia's remaining refineries remain open until at least mid-2027. The government is also in the process of implementing a minimum stockholding obligation (MSO) on industry for the first time.

Going forward, the Australian Government should focus on implementing more stringent measures to curtail oil consumption, particularly in transport and the mining sector, while simultaneously maintaining a strong focus on the security of oil supply.

Figure 10.1 Shares of oil in Australia's energy sector, 2000-2021



Oil is used for more than half of TFC and one-third of TES.

Source: IEA, (2022a).

Supply and demand

Upstream oil production

Australia has a fairly significant but declining upstream oil industry. Domestic oil production, including crude oil, condensate and natural gas liquids, stood at 440 kb/d in 2021, compared to 549 kb/d in 2010.

Oil production increased in 2019 following the start-up of the Greater Enfield, Ichthys and Prelude projects on the North West Shelf. However, total oil production, particularly of crude oil, has been trending downwards for much of the past two decades as new reserve developments have failed to compensate for the depletion rate of existing fields.

Australia's conventional oil reserves (proved or probable) were estimated at 1.8 billion barrels in 2019, equivalent to about 14 years of current production. Due to geological and other factors, there are thought to be few opportunities to utilise enhanced oil recovery or similar initiatives to slow or reverse the decline of Australia's existing oil fields.

Australia is believed to have significant unconventional oil resource potential, including shale oil, tight oil, basin-centred oil and oil shale. Oil shale is the only unconventional oil resource that has been exploited, but there is no longer any commercial production of oil shale in Australia. The production of Australia's unconventional resources is challenging due to a number of factors, including high drilling, fracking and transport costs in remote regions.

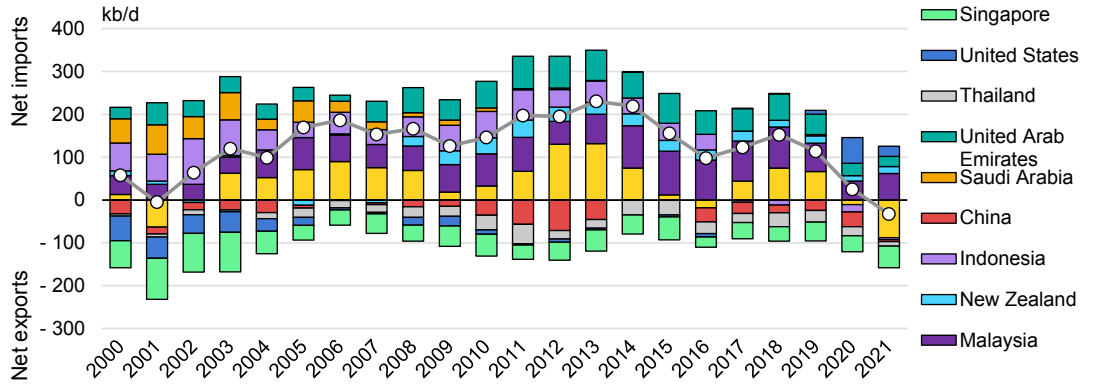
Crude oil, natural gas liquids and feedstock trade

Despite production being significantly lower than a decade ago, Australia became a net exporter of crude oil, natural gas liquids and refinery feedstocks in 2021, after having been

a net importer for more than two decades; this is a result of significant rationalisation of refining capacity. Net exports of crude oil, natural gas liquids and refinery feedstocks stood at 32.3 kb/d in 2021, compared to net imports of 230.6 kb/d in 2013 (Figure 10.2).

Malaysia has historically been Australia's largest source of crude oil and refinery feedstocks, with net imports from Malaysia of 62.2 kb/d in 2021. Net imports from the United States grew substantially in 2020 but fell back in 2021 (23.4 kb/d). Australia is also a relatively significant net importer from the United Arab Emirates (24.5 kb/d in 2021). Australia is a net exporter to several Asian countries, including Singapore (50.2 kb/d in 2021), Thailand (10.7 kb/d) and China (4.7 kb/d in 2021).

Figure 10.2 Australia's crude oil, natural gas liquids and refinery feedstock net imports by country, 2000-2021



In 2021, Australia became net exporter of crude oil, as demand from local refineries declined substantially. Local production is exported as production fields are far from the refineries.

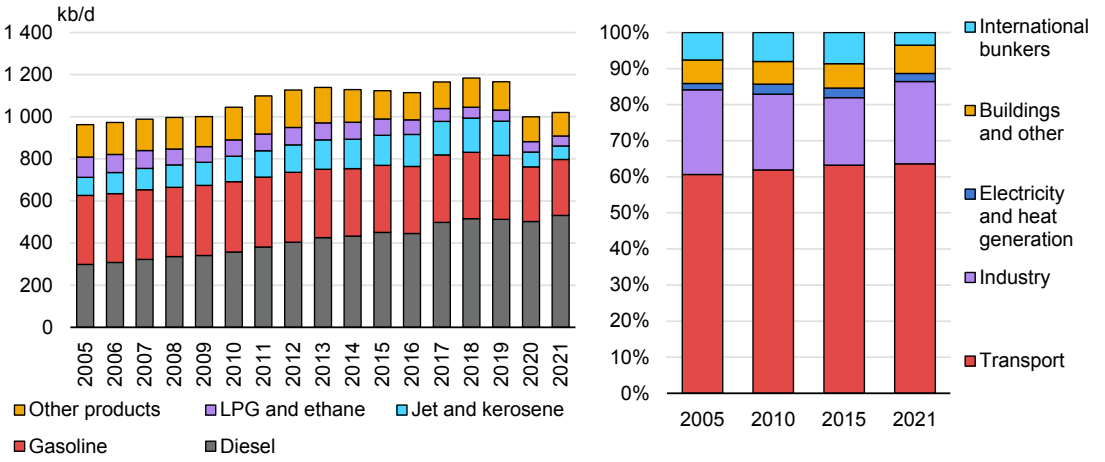
Note: kb/d = thousand barrels per day.

Source: IEA, (2022a).

Oil products demand

Total oil products demand in 2021 was 1 020 kb/d, up 2% from 2020 but 13% lower than in 2019 (Figure 10.3). Declining oil product consumption in 2020-2021 is largely a result of the Covid-19 pandemic. Prior to 2020, oil product demand had followed an upward trajectory since the mid-2000s. Average annual demand growth for oil products was around 1.5% from 2010 to 2019. Before 2020, demand growth had been driven by mining and transport, with diesel consumption growth being particularly strong, increasing from 358 kb/d in 2010 to 513 kb/d in 2021. In 2020, the transport sector accounted for 62% of total oil product demand, followed by the industry sector (22%). International bunkers accounted for 9% of demand. The government's 2019 Liquid Fuel Security Review found that growth in liquid fuels demand would likely continue until the mid-2030s. Future growth in oil product demand is expected to continue to be led by diesel from the transport and mining sectors.

Figure 10.3 Oil products demand by sector in Australia, 2000-2021



Oil product demand fell as a result of the impacts of the Covid-19 pandemic, but demand had been growing prior to 2020; demand growth is likely to resume for the next decade.

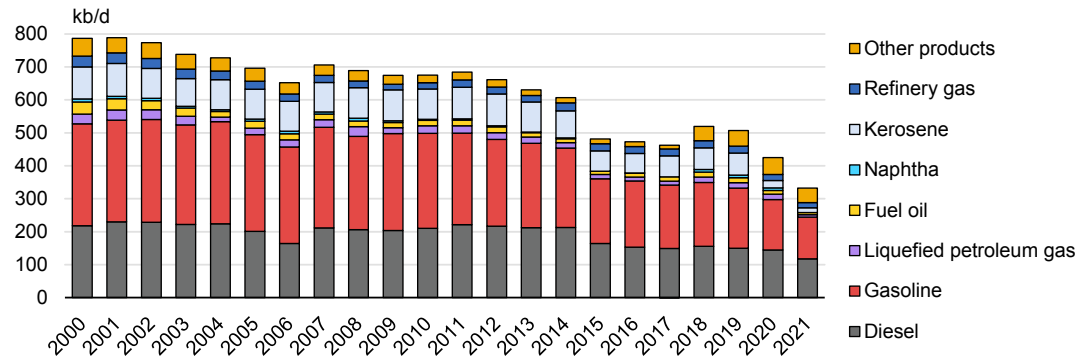
Notes: kb/d = thousand barrels per day; LPG = liquefied petroleum gas. 2021 data are estimated, and only include total demand. “Buildings” accounts for both residential and public service.

Source: IEA, (2022a).

Oil products production and trade

Oil products production has decreased substantially since 2000 following significant capacity rationalisation (see the section on “Oil supply infrastructure”). In 2021, total oil products production from refining was 333 kb/d, 51% lower than in 2011 (684 kb/d) and 58% lower than in 2000 (786 kb/d) (Figure 10.4). In 2020, gasoline accounted for 38% of production, diesel for 35% and kerosene for 5%.

Figure 10.4 Oil products production from refineries in Australia



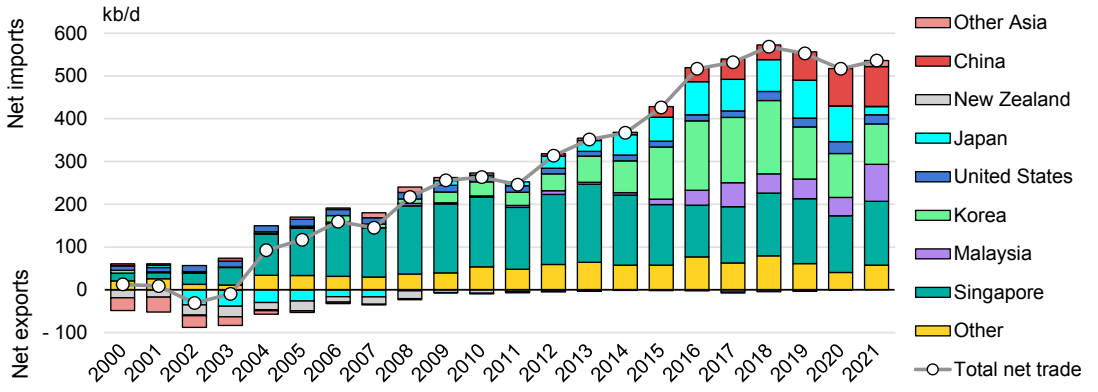
Oil products production has declined significantly due to rationalisation of refining capacity.

Note: kb/d = thousand barrels per day.

Source: IEA, (2022a).

With decreasing domestic production of oil products, Australia has become heavily reliant on imports, which now account for around 70% of oil product consumption. Most imports come from the Asia Pacific region; in 2021, total net imports reached 536 kb/d, including 149 kb/d from Singapore, 94 kb/d from Korea and 87 kb/d from Malaysia (Figure 10.5).

Figure 10.5 Australia's oil products net trade by country, 2000-2021



With declining domestic refining capacity, Australia has become dependent on oil product imports; imports are sourced mainly from countries in Asia Pacific.

Note: kb/d = thousand barrels per day.

Source: IEA, (2022a).

Oil policy

Fuel security measures

In recent years, the Australian Government has placed a strong focus on oil security by introducing measures focusing on improving the security of oil supply by supporting investments in oil storage, mandating minimum industry stockholding levels and providing financial incentives to refiners to maintain their operations.

These measures, as well as other recent fuel security measures that the Australian Government has implemented, include:

- A variable fuel security services payment (FSSP) to refiners.
- Strengthening the resilience of critical inputs to Australia's fuel market through a secure supply of diesel exhaust fluid.
- Financial support of up to AUD 302 million for infrastructure upgrades at refineries to support Australian refineries to produce improved quality fuels.
- An MSO for key transport fuels from the second half of 2022 (postponed due to the IEA collective actions, now scheduled for implementation from 1 July 2023), with diesel stocks increasing a further 40% above the baseline level in mid-2024 (see the "Oil emergency response policies and measures" section).
- The AUD 260 million Boosting Australia's Diesel Storage Program to increase diesel storage capacity.
- The purchase of oil to be held in the United States' Strategic Petroleum Reserve (US SPR), now sold due to IEA collective action.
- The modernisation of Australia's current suite of liquid fuel legislation to support a more effective response if market disruptions occur.
- The modernisation of Australia's petroleum statistics information management.

Support for refining operations

The FSSP, enabled under the Fuel Security Act 2021, provides refiners with a payment for the production of jet fuel, gasoline and diesel during periods when it is determined that the refineries are loss-making. The guarantee of payments during loss-making periods has been made in return for a commitment on the part of the refiners to continue refining operations until at least June 2027 (with an option to extend this to 30 June 2030). Australia's remaining refiners (Ampol and Viva Energy) have cited the FSSP as a crucial factor in their decisions to keep their refineries open.

In addition to the FSSP, the government is deploying up to AUD 302 million by 2024 through the Refinery Upgrades Program to support Australia's two domestic refineries to upgrade their facilities so they can produce better quality fuels. Phase 1 of the programme provides up to AUD 250 million through co-funded grants, with refineries paying 50% of the costs to produce ultra-low sulphur gasoline (10 parts per million). If the government chooses to improve fuel quality further (see below), a further AUD 52 million could be made available to refiners for capital costs associated with any additional upgrades required to meet the new fuel quality standards, through a Phase 2 of the programme.

Biofuels

There are no federal biofuel mandates in Australia and there are no plans to implement one. However, Queensland and New South Wales have state-level biofuel mandates for ethanol and biodiesel (see Chapter 5 for further information). In 2021, ARENA developed a bioenergy roadmap for Australia to enhance the growth of its bioenergy sector.

Fuel quality standards

Australia's fuel quality standards are some of the least stringent in the IEA. In 2019, the government established a schedule to limit the sulphur content in gasoline to 10 parts per million by 2027. In 2022, this deadline was brought forward to 2024 after the government provided AUD 250 million in funding to Australia's two remaining refineries for upgrades to facilitate the production of low-sulphur gasoline. The government is also considering options to reduce the aromatics content of Australian gasoline to align with international best practices. This is technically challenging for the petroleum industry due to restrictions on the use of methyl tert-butyl ether and other oxygenates in Australia.

Australia is also investigating the implementation of new biofuels standards for renewable diesel and B20 (20% biodiesel and 80% diesel).

Diesel exhaust fluid

Australia currently only has one manufacturer capable of producing urea for diesel exhaust fluid (DEF) production, Incitec Pivot's Gibson Island plant, which was set to close in December 2022. All other DEF enters the Australian market as imported DEF, or imported technical grade urea, which is then blended onshore. Australia currently has 19 DEF manufacturers, 16 of which are on the east coast. Products can be relatively easily moved around the country, noting that DEF is more complex and expensive to store and transport and has a shelf life of around three to six months. Technical grade urea in a dry form can be stored for much longer in cool, dry conditions.

Ensuring Australia's continued access to DEF will keep key transport and logistics services operational and prevent the harmful economic impacts of a disruption, as 24% of heavy vehicles require DEF. It is estimated that the Australian economy may experience losses of up to hundreds of millions of dollars per day, as a disruption would impact critical sectors reliant on modern diesel engines.

On 15 September 2022, the government announced a comprehensive package of measures to enhance the resilience in the Australian DEF market worth AUD 49.5 million over four years to 2025-2026. The package will establish a government-controlled strategic stockpile, support domestic manufacturing through a competitive grants programme and improve market transparency through stock-level reporting. The package includes:

- a government-controlled stockpile of technical grade urea, providing effective government response to support the Australian market if needed
- a competitive grants programme to deliver sovereign manufacturing capability, supporting DEF resilience in a longer disruption
- establishing a data collection and reporting framework for the DEF market to increase transparency and assist in avoiding future supply shortages.

Market structure

There have been significant structural changes in the Australian downstream oil market in the past decade, including the closure of several refineries and the exit of a number of oil majors.

Wholesale and retail

Following the closure of two refineries operated by BP and ExxonMobil in 2021, the wholesale sector consists of two vertically integrated refiner-wholesalers (Ampol and Viva Energy) and large importer-wholesalers (BP, ExxonMobil, United, Chevron Australia and Liberty).

In 2019, the former Caltex Australia was renamed Ampol, following Chevron's decision to terminate its licensing agreement for the use of the Caltex brand in Australia. Having sold its 50% share in Caltex Australia in 2015, Chevron re-entered the Australian market in 2020, following its acquisition of Puma Energy's Australian operations.

There are currently around 6 900 retail fuel sites across Australia. The market has seen an increase in independent retail chains, with the market share of independents increasing from 7% in 2010 to 25% in 2020. In 2019, UK-based retailer EG Group acquired the fuel retail business of the Woolworths supermarket chain, one of Australia's largest fuel retailers.

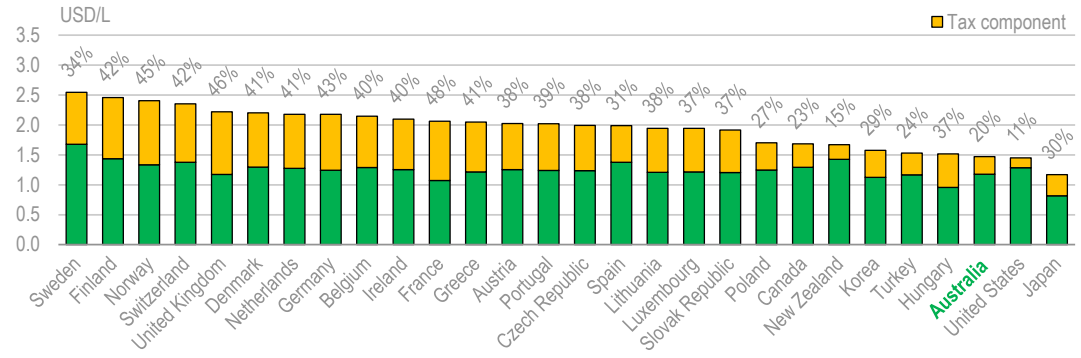
Prices and taxes

Fuel prices in Australia are among the lowest of all IEA countries. As of the end of 2021, the automotive diesel price was the third-lowest among IEA countries, at 1.17 USD/L, with a tax rate of 36% (Figure 10.6). RON 95 gasoline was the fourth-lowest among IEA countries, priced at 1.3 USD/L, with a tax rate of 33% (Figure 10.7). In comparison, the

average price for automotive diesel among IEA countries was 1.58 USD/L, while the average price for premium unleaded gasoline was 1.73 USD/L.

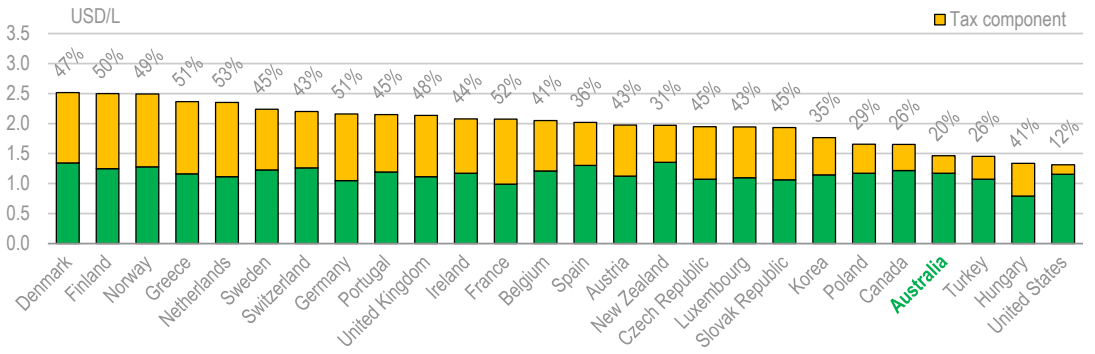
The Liquid Fuel Emergency Act 1984 stipulates that the government should not seek to interfere with market pricing of oil products, even in the event of a fuel supply emergency.

Figure 10.6 Price comparison for automotive diesel in the IEA, 2Q 2022



IEA. CC BY 4.0.

Figure 10.7 Price comparison for unleaded gasoline (95 RON) in the IEA, 2Q 2022



IEA. CC BY 4.0.

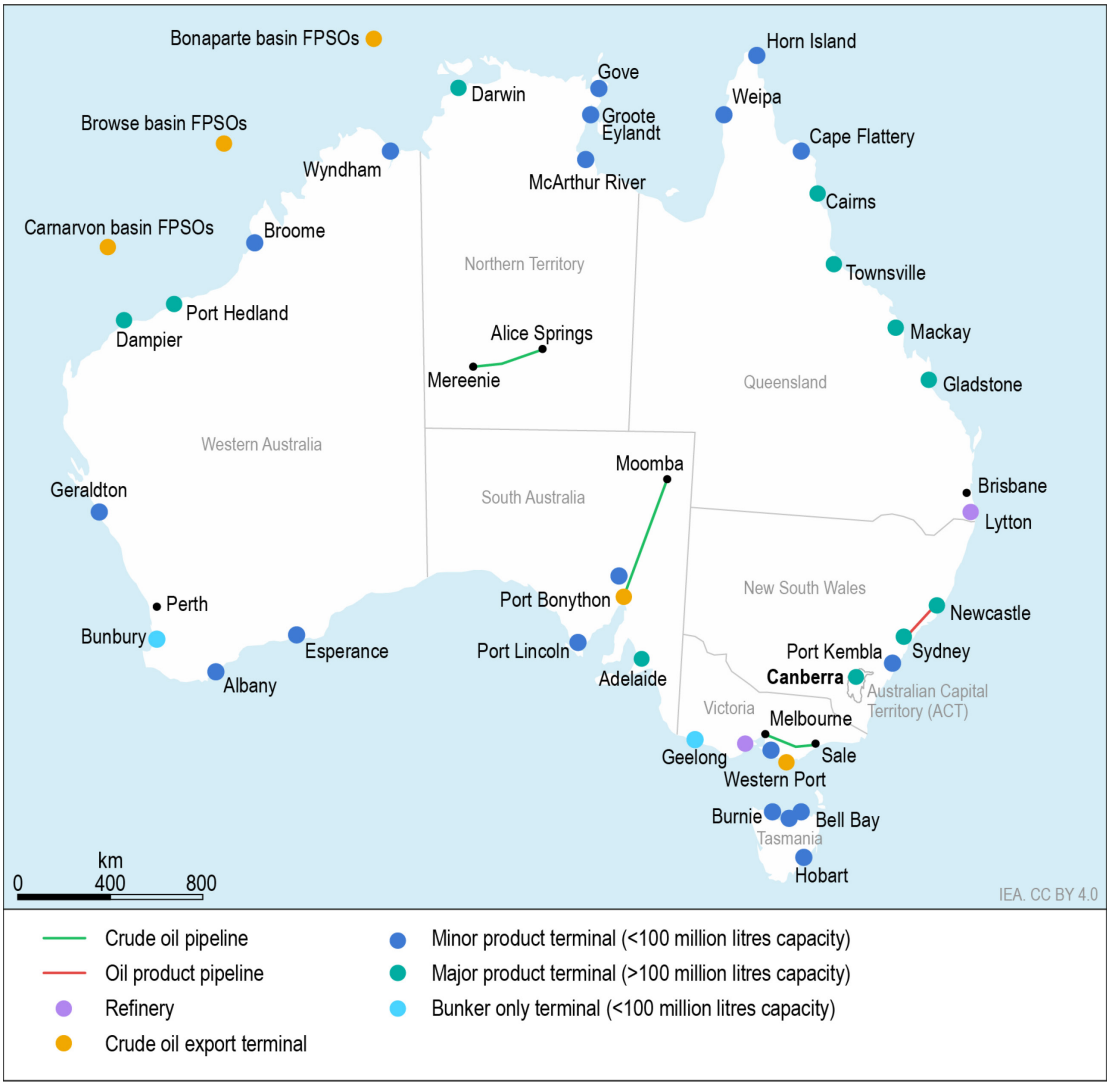
Automotive diesel and unleaded gasoline prices in Australia are relatively low, with a lower tax rate than most other IEA member countries.

Notes: USD/L = US dollar per litre. Automotive diesel data are unavailable for Denmark, Estonia, Luxembourg, Mexico and the United Kingdom. Premium unleaded gasoline (95 RON) data are unavailable for Denmark, Estonia, Japan, Luxembourg, Mexico and the United Kingdom.

Source: IEA, (2022b).

Infrastructure

Figure 10.8 Map of oil infrastructure in Australia



Notes: FPSO = floating production storage and offloading. The Kwinana (Freemantle) and Altona (Melbourne) refineries ceased operations in 2020.

Source: IEA, (2022).

Refineries

There are two remaining operational refineries in Australia, with a total atmospheric distillation capacity of 229 kb/d. The 120 kb/d Geelong refinery in Victoria (Melbourne) is owned by Viva Energy, while the 109 kb/d Lytton refinery in Queensland (Brisbane) is owned by Ampol (formerly Caltex Australia).

Australian refineries use both domestic and imported crude, primarily from the country's Bass Strait production in the south, and from Southeast Asian producers. For much of the past decade, the reliance on imported crude has steadily increased due to a lack of infrastructure connecting Australia's major oil fields with remaining refining capacity.

Two refineries ceased operating in 2021; the 146 kb/d Kwinana refinery in Western Australia (owned by BP) and the 80 kb/d Altona refinery in Victoria (owned by ExxonMobil). The Altona refinery is currently being converted into a fuel import terminal. BP is planning to repurpose the Kwinana refinery site as a "clean energy hub", potentially to include the production of green hydrogen.

The closures are the latest in a series of refinery shutdowns in Australia; the 85 kb/d Clyde (Sydney), the 125 kb/d Kurnell (Sydney) and the 102 kb/d Bulwer (Brisbane) refineries closed in 2012, 2014 and 2015, respectively, and were all subsequently converted into import terminals. Refinery closures have been driven by competition from new, large-scale refineries in Asia, and a global trend of oil majors divesting from the refining sector.

Viva Energy reportedly considered the closure of the Geelong refinery in 2021 but secured financial assistance from the government to maintain its operations. The FSSP scheme, introduced in 2021, is designed to maintain the long-term operation of Australia's remaining refineries (see "Oil policy" section).

There are a number of planned projects at Australia's two remaining oil refineries related to the production of low-carbon fuels. In 2021, Viva Energy announced a strategic alliance with Hyzon Motors for the potential development of a green hydrogen manufacturing and refuelling hub at Geelong. The company is also seeking government approval to develop an LNG import terminal adjacent to the refinery site. Also in 2021, Ampol announced an agreement with Fusion Fuel Green PLC to install a demonstrator plant to produce green hydrogen at the Lytton refinery site.

Table 10.1 Crude oil refineries in Australia

Refinery	Owner	Capacity (b/d)
Geelong	Viva Energy	120 000
Lytton	Ampol	109 000
Total		**229 000**

Note: b/d = barrels per day.
Source: IEA, (2022c).

Transport

A significant amount of oil product transport is by road tanker from refinery sites and import terminals to storage depots and end-users. A small quantity of oil products is also transported by rail and coastal shipping. Australia's oil ports are geographically widely distributed across the country, with the largest being the Port of Brisbane.

There are three main crude oil pipelines:

- Santos operates the 659 km Moomba-Port Bonython pipeline in South Australia
- Santos also operates the 796 km Jackson-Moonie pipeline in Queensland
- Esso/BHP Billiton operates the 185 km Longford-Long Island pipeline in Victoria (south-east of Melbourne).

There is one refined product pipeline, the 211 km Sydney-Newcastle pipeline in New South Wales.

Storage

Australia has ten main oil storage facilities geographically distributed throughout the country, with at least one per state or territory. Total reported oil storage capacity in Australia is around 60 mb, including 26 mb for crude oil and condensate and over 35 mb for oil products (17.16 mb of diesel, 12.8 mb of gasoline and 5.66 mb of jet fuel capacity).

Most of the storage capacity is owned by the country's main fuel wholesalers. However, a significant amount of capacity is also held by several independent terminal operators, including Vopak, Stolthaven and ANZ Terminals.

In expectation that diesel consumption will continue to rise in the medium term, the Australian Government has noted a particular need to increase diesel storage capacity. The Boosting Australia's Diesel Storage Program (see "Oil policy" section), provides up to AUD 260 million in competitive grants to build additional diesel storage capacity. These facilities are being funded with the intention of facilitating Australia's MSO (see "Oil emergency response policies" section). As of late 2022, nine projects had been approved under the programme, but several projects have not yet commenced construction.

Oil emergency policy and stockholding

Oil emergency policy

The Liquid Fuel Emergency Act 1984 (LFE Act) details the roles and responsibilities of stakeholders, as well as a number of mandatory measures that can be implemented in the event of a major oil supply disruption that impacts multiple regions. The LFE Act and associated guidelines grant the government broad powers to control the production, distribution, sale and use of liquid fuels across Australia in an emergency. To date, the LFE Act has never been invoked. The government is in the process of modernising the LFE Act.

Responsibility for emergency response lies with the relevant ministers in individual states and territories for localised disruptions. Each state and territory have legislation to address liquid fuel shortages that are contained within its jurisdiction.

As set out in the National Liquid Fuel Emergency Response Plan, the Australian Government's policy is, where possible, to allow industry to manage fuel supply shortfalls without government intervention. If market forces cannot resolve the supply shortfall, the government would initially consider seeking the voluntary co-operation of industry to increase supply and assist in encouraging demand restraint, as well as enacting measures to encourage consumers to voluntarily reduce their fuel consumption. Beyond this, the government has the ability to intervene through the use of compulsory measures, via activation of the LFE Act.

Oil stockholding

Currently, the Australian Government does not place an MSO on the oil industry. However, as part of the Fuel Security Act 2021, the government established an MSO for the first time, requiring fuel importers and refiners to maintain a level of gasoline, diesel and jet fuel stocks from the second half of 2022. However, in view of tightened global oil markets, and in conjunction with the IEA collective actions, the then government decided to postpone the implementation of the MSO until the beginning of 2023 at the earliest. The current

government has since finalised the necessary legislative arrangements and the MSO is scheduled to commence on 1 July 2023.

In 2019, Australia obtained its first public oil stocks, acquiring them through tickets via agreements with Hungary, the Netherlands, Spain and the United States; the programme to purchase stocks through tickets ended in June 2021. In 2020, Australia bought 1.7 mb of crude oil to be stored in the US SPR. However, the US SPR volumes were entirely released in June 2022 as the country's contribution to the IEA collective action of 1 March 2022. The government has not yet decided whether it will again buy crude oil for storage in the US SPR or seek to hold stocks outside Australia in general in the future, through tickets or other means.

Australia has remained non-compliant with the IEA 90-day net imports stockholding obligation since March 2012 (although countries are not deemed non-compliant with their IEA stockholding obligations for the duration of IEA collective actions). Since 2000, declining domestic oil production coupled with oil demand growth has resulted in a steady rise in net imports, and therefore the volume of oil stocks necessary to meet Australia's stockholding obligation. As of June 2022, Australia held oil stocks equivalent to 58 days of net imports.

Assessment

While oil product consumption declined in 2020-2021 due to the impact of the Covid-19 pandemic, the government expects that consumption will grow in the near term and growth will then persist into the 2030s. This is due to the continued and important role traditional liquid fuels play in Australia's energy mix and in supporting the country's critical services.

In the past, the extent of the Australian Government's ambitions to curtail oil demand has been unclear. The Future Fuels and Vehicles Strategy was launched in November 2021, but its ambitions for the penetration of alternative fuels in transport were considerably less ambitious than in many other IEA countries. The Australian Government has never taken action to implement federal biofuel mandates. While Queensland and New South Wales have state-level biofuel mandates for ethanol and biodiesel, these have not been successful in achieving a significant level of biofuels penetration.

To curtail oil consumption, the government needs to take stronger action to promote the use of alternative fuels in transport. Establishing clear aspirational targets for a reduction in oil consumption in transport could be a highly effective signal of the government's intentions and provide guidance to other targets for the uptake of alternative fuels in transport. It is also essential that attention be given to encouraging and assisting the mining sector, a key driver of oil demand, to reduce its oil consumption, particularly as there are many opportunities for displacing oil by alternative fuels in mining operations.

On the supply side, oil products production has decreased significantly following the closure of five refineries since 2012, including two in 2021, leaving Australia heavily reliant on imports. As a consequence of this increased reliance on imports, the security of oil supply has become a particularly pressing concern for the Australian Government. In recent years, it has commendably placed a strong emphasis on bolstering the security of oil supply, particularly through the various fuel security measures introduced as part of recent budgets.

The FSSP is a prudent short-term measure which should prevent the immediate closure of Australia's two remaining refineries. The government should continue to monitor the need for the FSSP and work in close consultation with industry when deciding whether or not to extend the scheme beyond 2030. The focus on increasing diesel storage capacity through the Boosting Australia's Diesel Storage Program is also well-judged, given the likelihood that Australia will become even more reliant on diesel imports in the coming decade as demand rises.

The introduction of an MSO on the oil industry is another commendable step that, once implemented, will enhance the security of oil supply and facilitate Australia's participation in any future IEA collective actions. While the implementation of the MSO has been rightfully delayed as a result of the ongoing 1 March and 1 April 2022 IEA collective actions, the government should ensure that it can be swiftly implemented as planned, and in consideration of the tightness in oil markets and if the IEA Governing Board has called an end to the collective actions.

After the ongoing collective actions have ended, Australia must resume the progress it made in recent years to comply with its IEA stockholding obligation. This will enhance domestic security of supply and solidify Australia's ability to contribute to a "worst case scenario" collective action.

Recommendations

The government of Australia should:

- Set medium- and long-term targets for reducing oil consumption in transport to complement the government's increased emissions reductions ambitions and provide direction to efforts to promote the uptake of alternative fuels and electric vehicles.
- Promote a reduction in diesel consumption by working with the mining sector to develop a plan to promote the electrification of ancillary equipment in the mining process.
- Maintain a strong focus on oil security and monitor the potential need to further incentivise the construction of additional storage capacity and extend the Fuel Security Services Payment.
- Ensure Australia's return to full compliance with its IEA stockholding obligation by taking all necessary measures, including implementing the minimum stockholding obligation and raising it sufficiently.

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11. Special focus on critical minerals

Key data

(2020)

Production *versus* global output; kt

Lithium: 40 kt vs. 82 kt, 49% of global production

Cobalt: 5.6 kt vs. 135 kt, 4.1% of global production

REEs: 20 kt vs. 240 kt, 8.3% of global production

Titanium (rutile): 200 kt vs. 1 000 kt, 20% of global production

Overview

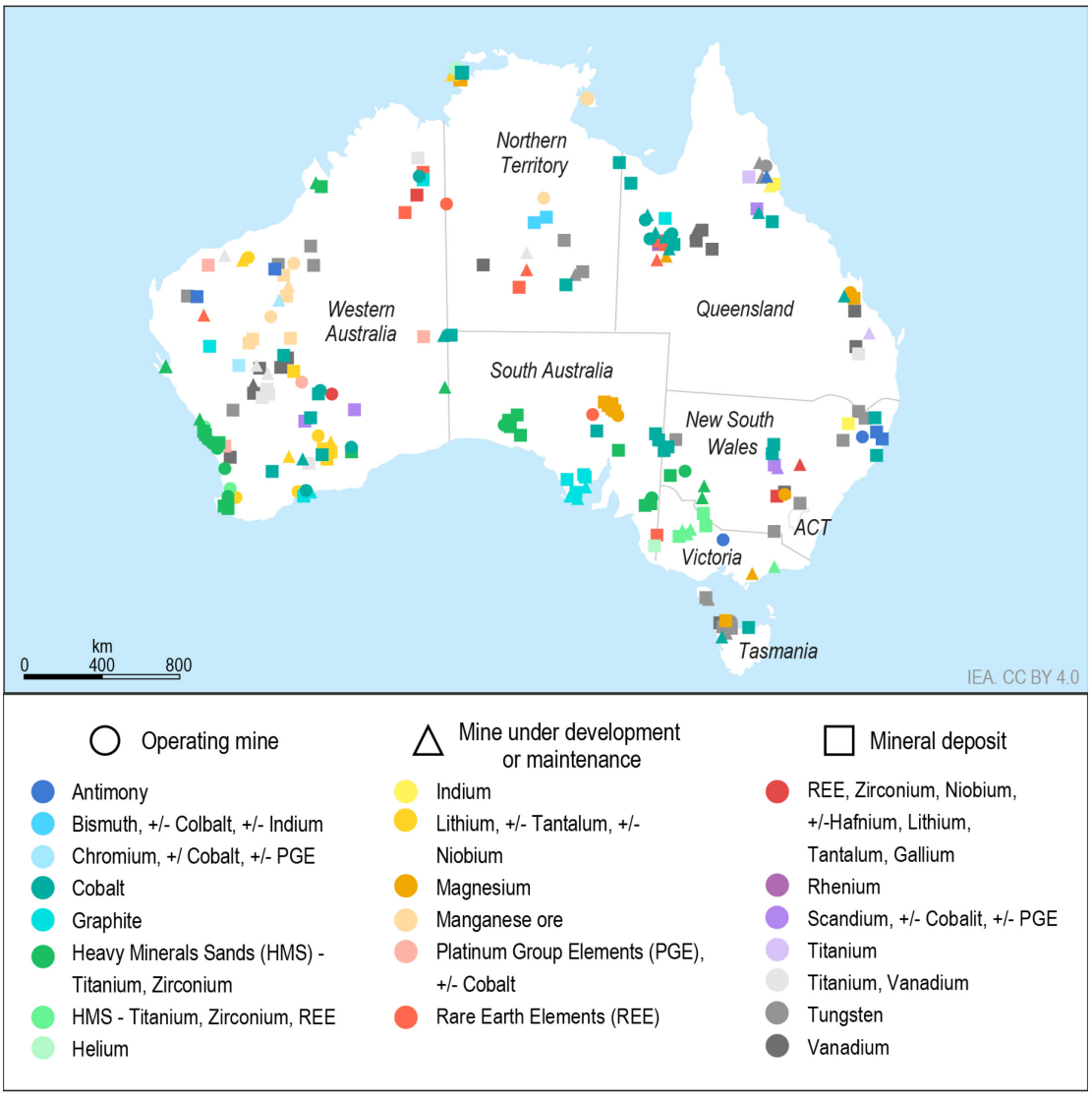
Australia is seeking to position itself as a key global source of critical minerals supply for decades to come. In light of recent events caused by Russia's invasion of Ukraine, and greater energy independence resulting from expanded clean energy production, critical minerals are not only critical to address climate change but are also essential to ensure security of energy supply and address energy poverty and affordability.

Critical minerals have become a fundamental part of the energy and electricity security landscape. As highlighted in the *World Energy Outlook 2022* (IEA, 2022), demand for critical minerals for clean energy technologies is set to increase by fourfold by 2030 due to the expanding deployment of renewables, EVs, battery storage and electricity networks. The largest increase in absolute volumes will be for copper, with current demand of around 6 Mt per year, increasing to 16 Mt in the case where net zero by 2050 pathways are seriously pursued. Other critical minerals will experience faster rates of demand growth, notably silicon for solar PV, rare earth elements for wind turbine motors and lithium for batteries. Both the extraction and processing of critical minerals are now highly concentrated geographically. Unless the need for stronger resilience and diversity in supply chains is addressed, there is a risk that the increasing use and importance of critical minerals could become a bottleneck for clean energy deployment.

Australia has more than doubled its share in the global market of critical minerals since 2015, which stands now at some 18%. It is still falling far short of China's dominance throughout the supply chain, which is a challenge for countries in terms of market development. Given generally higher production costs, mostly due to environmental, social and governance (ESG) factors, Australia is likely to leverage its extensive mining experience and invest heavily in processing capacities to build its position as a reliable global supplier.

According to recent IEA scenarios, none of the critical minerals currently have an announced global supply capacity sufficient to meet the massive ramp-up needed by 2030. This makes Australian potential more important if realised swiftly.

Figure 11.1 Australian critical minerals at operating mines and major deposits



Source: IEA, (2022).

Production and prospects

The Australian Government considers 26 resource commodities to be critical minerals. According to Geoscience Australia, these have been selected by assessing Australia's geological endowment and potential with global technology needs, particularly those of partner countries such as Canada, India, Japan, Korea, the United Kingdom and the United States. According to Geoscience Australia, out of the 26 minerals, as many as 16 have high or very high production potential in Australia, including key one's indispensable for clean energy technologies: lithium, cobalt, manganese and rare earth elements (Figure 11.1).

The Australian Critical Minerals Prospectus published in December 2022 by Austrade highlights more than 55 investment-ready critical minerals opportunities (Austrade, 2022). Together, during 2022, Australia's critical minerals project portfolio included 69 ventures with a total investment value of up to AUD 35 billion, around a 10% increase compared to 2020.

Australia holds the second-largest (after Chile) lithium resources globally at close to 7 Mt. It is already the biggest producer of lithium in the world, supplying about 50% of the world's lithium in the form of a mineral concentrate called spodumene. Australia's lithium production is almost entirely concentrated in Western Australia. In 2021, production totalled over 40 kt of lithium equivalent (212 kt of lithium carbonate equivalent) and is expected to rise sharply in the years to come. Australia's lithium production is forecast to increase by over 50% in the 2022-2023 financial year. The government expects that by 2025, annual production will reach close to 112 kt. The earnings from lithium exports will increase from AUD 4.1 billion in 2021 to AUD 9.4 billion in 2022-2023, although pricing is one of the major risk factors after the market collapse in 2018-2019. Over 2021, lithium prices more than tripled but have stabilised since mid-2022.

Although Australia has already begun producing lithium hydroxide, a final product for battery production applications, it mostly trades spodumene, which has to be processed through a multi-stage process to be ready for advanced applications. For that, Australia needs to develop its capacities to boost the clean technology economy in the country by facilitating the manufacture of higher value-added products and expanding its processing and refining capabilities to become a supplier of ready products to the world markets rather than selling only pre-treated ores. Critical minerals are generally difficult to process, given the diversity in structure, each requiring different purity of process and storage solutions. Currently, established projects also face technical and market constraints, impeding critical minerals' processing in Australia at a large scale. Several strategic governmental publications were developed, outlining the possible areas of collaboration between government and industry, and aiming to make critical minerals policies coherent across all Australian jurisdictions.

Australia is also among the world's largest resources of critical minerals, including tantalum, zirconium, titanium, lithium, cobalt, tungsten, vanadium, niobium, antimony and manganese ore; and a top five producer of rare earth elements, cobalt, manganese ore, zirconium and titanium. Australia's rare earth element production includes neodymium, praseodymium and dysprosium, which are central to permanent magnet production for wind turbines. Australia has the world's sixth-largest rare earth elements resource base and is one of the few sources of dysprosium outside of China.

Thanks to additional exploration and resource definition, Australia has increased its economic inventories for many critical minerals over the last few years, such as cobalt (a 7% increase), vanadium (a 23% increase), antimony (a 24% increase), tungsten (a 43% increase) and platinum group elements (a 185% increase). This positioned the country as a second global resource holder of not only lithium but also cobalt, tungsten and vanadium. Australia has potential for more undiscovered minerals. Well-established mining regions cover just 20% of Australia, while the remaining 80% is largely underexplored.

The international competitiveness of Australia's resources sector is underpinned by its advanced mining equipment, technology and services industry. There are approximately

6 000 Australian companies which directly serve the mining sector, supported by world-leading general technology vendors.

The rapid increase in the production and deployment of clean technologies in Australia also requires the development of new technologies in recycling, reuse, supply chain resilience and revolutionary mineral substitution know-how. This will also support the creation of high-quality skills within the community and address environmental concerns related to extensive mining.

Policies

The 2022 Critical Minerals Strategy is Australia's national policy strategy, elaborated under the previous government (DISR, 2022). Building on the first strategy of 2019, it lays out a national strategy for downstream processing and manufacturing opportunities by attracting investment, creating jobs, and supporting innovation and infrastructure. Its stated vision is to make Australia a global critical minerals powerhouse by 2030. The 2022 Strategy also added two new minerals to Australia's critical minerals list – high purity alumina and silicon – reflecting the expanding significance of mineral inputs in strategic applications like semiconductors and progressing electrification of energy use.

The 2021 Resources Technology and Critical Minerals Processing National Manufacturing Priority Roadmap emphasised how important it will be for Australia to develop manufacturing in critical minerals to capture added value for its economic growth.

The Modern Manufacturing Strategy Initiative reflects the AUD 1.5 billion investment the Australian Government announced in October 2020 to develop technology and critical minerals resources processing. Further development of the midstream sector, after its extraction and before its final processing, would also aid in strengthening the critical minerals industry and ensure Australian sovereignty of a strategically important resource.

In October 2022, the Australian Government announced that a refreshed National Critical Minerals Strategy was being developed in consultation with industry and community stakeholders, including traditional owners, to ensure it supports the government's priorities for developing the critical minerals sector. It will aim to ensure that the strategy reflects the important role Australia's critical minerals can play in helping Australia and international partners achieve their emissions reduction targets; the growth of Australia's domestic manufacturing sector; and Australia's ongoing commitment to the highest ESG standards.

The refreshed strategy will likely continue to focus on the importance of a stable supply of critical minerals by developing new sources of supply and establishing robust, diverse supply chains. The government consulted with stakeholders on the development of the strategy in late 2022 or early 2023 to seek input and ideas from the public on what is needed to grow the sector.

Government programmes in R&D

The Australian Government is also investing AUD 50.5 million to establish the Australian Critical Minerals Research and Development Hub to bring together various R&D expertise. The R&D Hub will build on Australia's world-leading research capabilities by drawing

together critical minerals expertise within CSIRO, Geoscience Australia, and the Australian Nuclear Science and Technology Organisation and connecting critical minerals projects with the scientific and technical expertise they need.

The hub will prioritise and advance significant critical minerals R&D projects, work with the research community and industry to build and commercialise Australian intellectual property and support R&D collaboration with Australia's international partners. One of the hub's main focuses will be the minerals needed for clean energy to help Australia and other countries achieve net zero emissions.

The Australian Government has also announced the Critical Minerals Development Program, which will provide AUD 100 million of co-funded grants to support early- and mid-stage critical minerals projects to enable them to overcome market and technical barriers to development. The grant funding will target strategically significant projects.

The Australian Government will additionally deliver the AUD 15 billion National Reconstruction Fund, which will provide loans, guarantees and equity to support projects that create secure, well-paid jobs, drive regional development, and invest in national sovereign capability, broadening and diversifying Australia's economy. Another AUD 1 billion is committed to the Value-Adding in Resources Fund, which looks to expand mining science technology.

The Australian Government also released its revised *Outlook for Selected Minerals in Australia* in March 2021 (DISR, 2021), which provides a market outlook for critical minerals that hold significant potential for Australia and have important uses in energy supply and technology (to be updated regularly). The government has yet to assess Australia's exposure to global supply chain risks for its clean energy transition.

The government's main actions planned to implement these policies and accelerate the development of the critical minerals sector include:

- derisking projects (project facilitation, providing technical support, and making strategic investments to scale up processing and lock in finance and offtake for production)
- creating an enabling environment (R&D to grow the sector, standards and accreditation to keep building the country's advantage, shared infrastructure and precincts to attract investment)
- further strengthening international partnerships
- whole-of-government policies to support the sector (including through the Critical Minerals Development Program to conduct feasibility studies, pilot testing, building demonstration plants, engineering design work).

Institutional governance for critical minerals

The Australian Government has established an extensive structure within the administration and beyond to support the critical minerals industry in Australia.

The Critical Minerals Office (CMO, formerly the Critical Minerals Facilitation Office) was established in January 2020 as the main Australian Government policy co-ordination body in the sector. It aims to grow Australia's critical minerals sector; generate additional profit by moving the sector into downstream processing; and contribute to the diversification of

international supply chains at a global level. The CMO operates in close collaboration with a variety of agencies in the domestic and international critical minerals institutional ecosystem.

CSIRO and the Australian Nuclear Science and Technology Organisation are working with the CMO to unlock the full economic potential of Australian critical minerals by providing access to world-leading research and technical services.

Additionally, Geoscience Australia, the country's pre-eminent public sector geological authority, is working to build Australia's resource wealth through investment stimulation, pre-competitive geological research and technology advice.

The Australian Trade and Investment Commission is responsible for the promotion, attraction and facilitation of foreign direct investment into Australia and co-ordinates the interests of global players in Australia's critical minerals sector through diplomatic representations in the world.

The current Australian Government has strongly reiterated the importance of critical minerals and announced a number of major commitments relating to this field, including through the AUD 15 billion National Reconstruction Fund, with up to AUD 1 billion earmarked for the broader resources sector. The government has also announced it is developing a National Battery Strategy that will guide governments and industry towards a shared vision of an end-to-end domestic battery industry.

The Critical Minerals Facility, with a budget of AUD 2 billion, was established to be a loan facility for Australian critical minerals projects, to complement any finance which might not be available in the private sector. It is administered by Export Finance Australia.

Global collaboration

Australia is active globally to accelerate regional and global co-operation to boost critical minerals uptake. Australia collaborates with a range of countries, including India, Japan, Korea, the United Kingdom, the United States, the European Union and its member states. These engagements help to address potential supply chain risks; advance research; and promote ethical, sustainable practices.

In July 2022, the Australian Government and the IEA co-hosted the Sydney Energy Forum. The forum agreed to accelerate project investments and partnerships that expand and diversify the supply of critical minerals and other key materials in the Indo-Pacific region.

Australia is a member of the Minerals Security Partnership, which includes its founding members Canada and the United States, along with Finland, France, Germany, Japan, Korea, Sweden, the United Kingdom, and the European Commission.

Additionally, Australia is a founding partner of the Energy Resource Governance Initiative, designed to promote sound mining sector governance and resilient energy mineral supply chains. At the initiative's one-year anniversary, members recognised the increasing demand for energy resources, including critical minerals. In line with this recognition, the CMO is continuing to promote Australian ethical and environmental standards internationally.

Australia is also deeply engaged in co-ordinating national and international policies and best practices through the IEA's Critical Minerals Working Party. The working party was established in October 2022 and aims to build a leading global platform for exchanging information, discussing ESG standardisation and building a security of supply mechanism for critical minerals.

Environmental, social and governance standards

The government is working to advance international ESG standardisation to make critical minerals supplied to global markets sustainable. The Australian critical minerals industry is well-positioned globally to meet emerging ESG requirements. The Australian Government is committed to promoting the industry's ESG credentials to trading partners to ensure Australia is a supplier of choice. The CMO provides support to industry on how it can best promote their ESG credentials.

Assessment

Australia is seeking to position itself as a key global producer of critical minerals supply to accelerate the production and uptake of clean energy technologies. Russia's invasion of Ukraine has been a wake-up call for many countries to ensure the energy independence of their critical minerals supply, vital for expanding all low emissions technologies. In this context, critical minerals availability and trade become vital for the security of energy supply.

Since 2015, Australia has more than doubled its share in the global market of critical minerals, which stands now at 18%. China has full dominance throughout the supply chain. This is a challenge in terms of Australia's market development, given the generally higher cost of production, mostly due to the cost of labour and energy, standards, and economies of scale.

Australia is leading globally in lithium production, supplying 50% of global output, and aims to almost triple its production by 2025 to 112 kt. The earnings from lithium exports will increase from AUD 4.1 billion in 2021 to AUD 9.4 billion in 2022-2023, which is following the tripling of lithium prices on world markets during 2022.

With its globally significant deposits, Australia is also among the top five potential producers of cobalt, rare earth elements, vanadium, tungsten and manganese ore. Investment is driven by a highly skilled workforce in the mining sector, decades-long expertise in geological and geophysical research, a strong R&D base, and reliable ESG credentials.

Focused on its role as a major producer of critical minerals, Australia has not yet assessed the specific exposure of the Australian energy system to critical minerals availability. Australia's general energy security assessment process provides a forum to consider this risk, alongside other risks to domestic energy supply, prices and system resilience.

However, amid fragmented supply chains and large market concentration in China, Australia will need to make significant efforts, including through the IEA's Critical Minerals Working Party, to help build transparent and secure markets to attract large investments on a global scale beyond lithium.

Australia has a truly robust institutional governance to support its expanding critical minerals industry across the value chain. While the CMO is the whole-of-government co-ordination office, CSIRO, the Australian Nuclear Science and Technology Organisation, and Geoscience Australia pursue scientific leadership.

The CMO is accelerating its bilateral and multilateral engagement by building important regional and global coalitions for sustainable and secure clean energy supply chains. Australia is a founding member of several important initiatives, such as the ERGI; the Sydney Energy Forum; the US Minerals Security Partnership, which formed the basis for the new bilateral Australia-Japan critical minerals pact; and the IEA's Critical Minerals Working Party.

A refreshed National Critical Minerals Strategy 2023 will replace Australia's 2022 Critical Minerals Strategy (DISR, 2022) published under the previous government. The latter was based on the first comprehensive Critical Minerals Strategy published in 2019 and its national strategy for mining, downstream processing and manufacturing by attracting investment, creating jobs, supporting innovation and connecting opportunities with infrastructure. Its vision is to make Australia a global critical minerals powerhouse by 2030. The 2022 Strategy saw the addition of two new minerals to Australia's critical minerals list – high purity alumina and silicon – reflecting the expanding significance of mineral inputs in strategic applications, like semiconductors and solar panels. The new strategy will enter into force in 2023 and continue to focus on the importance of a stable supply of critical minerals, by developing new sources of supply and establishing robust, diverse supply chains.

The government supports production capacity in the country through public funding of pre-commercial mapping data; grants to early- to mid-stage projects; loans through dedicated investment facilities and instruments, for instance, binding offtake arrangements.

The government announced a number of major commitments relating to this field, including through the AUD 15 billion National Reconstruction Fund, with up to AUD 1 billion earmarked in indirect support to the sector. The government recently announced a National Battery Strategy to explore maximising value added and developing national technology potential for both supplying domestic and international markets with Australian-produced batteries. The AUD 2 billion Critical Minerals Facility aims to provide loans to finance eligible Australian critical minerals projects where private sector finance is unavailable or inadequate, helping crowd-in private investment.

Australia needs to look for solutions to increase its supply base faster, overcoming long project lead times and significant concentration of the global downstream market, if it wants to scale up investments and bring products to market sooner.

Australia's high ESG standards are crucial for the responsible and sustainable production of critical minerals. To create a level playing field, the government should also promote these standards globally, fostering high ESG conditions.

Rapid scaling up of production and clean technologies deployment in Australia also calls for the development of alternative supply- and demand-side technologies like recycling, reuse capabilities, supply chain resilience and breakthrough technology for minerals' substitution. This will also support the creation of high-quality skills within society.

Australia appears to have high potential for large-scale production from many of its critical minerals resources thanks to its human and technological experience in this area. However, mineral processing, today very limited in Australia, remains the largest challenge for the Australian Government. And it is only through ESG-standardised processing that the critical minerals needed for the global transitions can finally be clean and sustainable. Australia holds the key to boosting transparency in this market globally.

Recommendations

The government of Australia should:

- Boost Australia's unique resource position by supporting an investment environment with world-class environmental, social and governance standards and government support to attract private investment and stimulate the growth of new sectors of the critical minerals supply chain.
- Play an active role in strengthening international collaboration to create predictable and transparent markets for critical minerals globally. Make the best use of the IEA's Critical Minerals Working Party as a forum to identify and tackle barriers to sustainable critical minerals supply chains and promote standardised ESG approaches globally.
- Streamline permitting procedures alongside state and territory governments and new projects' lead times to allow for accelerated development of mining and processing capacities in the country while engaging local communities and contributing to their socio-economic development.
- Promote technology innovation along the value chain by stepping up research and development efforts on both the demand and production sides to enable more efficient use of materials, recycling and material substitution and to increase available supply for a secure global energy transition.
- Assess Australia's exposure to critical minerals supply chain risks globally, for instance, through the National Energy Security Assessment.

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ANNEX A: Review team and supporting stakeholders

Review criteria

The Shared Goals, which were adopted by the International Energy Agency (IEA) Ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the IEA's in-depth reviews. The Shared Goals are presented in Annex D.

Review team and preparation of the report

The in-depth review team visit took place from 27 June to 4 July 2022. The review team met with government officials, energy suppliers, market participants, public and private sector interest groups, consumer associations, research institutions, and other organisations and stakeholders.

The report was drafted on the basis of the information obtained during these meetings, the team's preliminary assessment of Australia's energy policy, the Australian Government's response to the IEA energy policy questionnaire, and information on subsequent policy developments from the government and private sector sources. The members of the team were:

IEA member countries

Mr Robert McGuinness, Ireland (team leader)

Mr Gwenaël Podesta, France

Mr Jelte de Jong, Netherlands

Ms Sandra Gamble, New Zealand

Ms Celeste Marshall, United States

Mr Masataka Yarita, Japan

Mr Kazuhiko Saito, Japan

International Energy Agency

Mr Jason Elliott, Acting Head of the Energy Policy and Security Division

Ms Sylvia Beyer, Senior Energy Policy Analyst and in-depth review co-ordinator

Mr Ronan Graham, Energy Security Analyst

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The review team extends its warm thanks to, Ms Alison Fleming, Mr Kristofer Gilmour, Ms Zeba Anjum and Ms Harini Epa for their effective management and co-ordination of the review, notably the peer expert visit, their tireless efforts and professional support at all times, and prompt responses to the requests throughout the review process.

This review was prepared under the guidance of Mr Keisuke Sadamori, Director, Energy Markets Directorate, IEA, and Mr Jason Elliott, Acting Head of the Energy Policy and Security Division, IEA. Ms Sylvia Beyer managed the review and finished drafting the final report. Mr Ronan Graham wrote Chapters 9 and 10. Mr Milosz Karpinski drafted Chapter 11. Ms Roberta Quadrelli and Ms Erica Robin from the Energy Data Centre led the energy data and statistics discussions during the visit. Mr Alessio Scanziani, Ms Clémence Lizé, Ms Eleonore Carre and Ms Su Min Park prepared the energy data sections of the report. Mr Alessio Scanziani also supported the energy efficiency analysis.

The following IEA staff provided insights and expert comments, chapter reviews and helpful updates: Mr Kieran McNamara, Mr Timothy Goodson, Mr Carlos Fernández Alvarez, Mr Nicholas Howarth, Ms Zoe Hungerford, Ms Rena Kuwahata, Mr Jean-Baptiste Dubreuil, Mr Simon Bennett and Mr Gergely Molnar.

Special thanks to the IEA secretariat with regard to the data, publication and editing. Ms Eleonore Carre, Mr Alessio Scanziani, Ms Clémence Lizé and Ms Su Min Park supported the timely preparation of the report with data, analysis, figures, tables and maps. Mr Alexandre Bizeul, Mr Pedro Carvalho and Mr Domenico Lattanzio provided support on statistics and data. Ms Isabelle Nonain-Semelin managed the editing process and finalised the production, and Ms Astrid Dumond the production process. Ms Jennifer Allain edited the report. All maps were prepared by Ms Eleonore Carre and produced by Ms Tanya Dyhin.

Organisations visited

AGIG Minerals Council of Australia

AGL

Alinta

Ampol

ANU Energy Change Institute

APA Group

Australasian Convenience and Petroleum Marketers Association (ACAPMA)

Australian Alliance to Save Energy

Australian Competition and Consumer Commission (ACCC)

Australian Energy Market Commission (AEMC)

Australian Energy Market Operator (AEMO)

Australian Energy Regulator (AER)

Australian Gas Networks

Australian Hydrogen Council

Australian Industry Group

Australian Institute of Petroleum (AIP)

Australian Petroleum Production and Exploration Association (APPEA)

Australian Pipeline Gas Association (APGA)

Australian PV Institute

Australian Renewable Energy Agency (ARENA)

Australian Sustainable Built Environment Council

BHP (Mitsubishi Alliance)

Bioenergy Australia

BP

Bravus Mining and Resources, Adani

Business Australia (BA) – trading name for NSW Business Council

Caltex

Chemistry Australia

Clean Energy Council

Clean Energy Finance Corporation (CEFC)

Clean Energy Investor Group

Clean Energy Regulator (CER)

Climate Change Authority (CA)

Climate Energy Finance Studies

Climate Works

CO2CRC

Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW)

Commonwealth Department of Industry, Science and Resources (DISR)

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

CS energy

Delta Electricity

Department for Energy and Mining (South Australia)

Department of Energy and Public Works (Queensland)

Department of Planning, Industry and Environment (New South Wales)

Department of State Growth (Tasmania)

Energy Consumers Australia (ECA)

Energy Efficiency Council

Energy Lab

Energy Networks Australia

Energy Policy (Western Australia)

Environment, Planning and Sustainable Development (Australian Capital Territory)

Evergen

ExxonMobil

Future Battery Industries CRC

Future Fuels CRC

Gas Energy Australia

Glencore

GlobalPowerEnergy

Green Building Council of Australia

Hyundai

Iberdrola Australia

Jemena

Low Emissions Technology Australia (LETA)

Major Energy Users

Materials Energy Research Laboratory, University of Sydney

Minerals Council of Australia

Monash Energy Institute (MuEI)

National Offshore Petroleum Safety and Environmental Management Authority (NPOSEMA)

National Offshore Petroleum Titles Administrator (NOPTA)

Office of Sustainable Energy Territory Renewable Energy (Northern Territory)

Origin

Origin Energy

Otherlab (Rewiring Australia)

Pollination

Santos

Shell Australia

Smart Energy Council

St Vincent de Paul

University of New South Wales

University of Adelaide/Scaling Green Hydrogen

Viva Energy

Yancoal

ANNEX B: Statistical notes and energy balances

Unit: PJ

SUPPLY		1973	1990	2000	2010	2019	2020	2021
TOTAL PRODUCTION		**2846.5**	**6595.4**	**9778.7**	**13538.3**	**18656.1**	**18957.6**	**17854.7**
Coal		1685.2	4442.3	6890.6	10323.1	12596.4	12334.9	11467.6
Peat		-	-	-	-	-	-	-
Oil		830.9	1215.3	1419.8	1069.2	721.9	875.0	785.1
Natural gas		141.6	717.6	1194.9	1862.3	4939.9	5329.2	5140.2
Biofuels and waste[1]		147.7	165.9	210.8	205.0	206.9	197.7	200.9
Nuclear		-	-	-	-	-	-	-
Hydro		41.1	50.9	58.9	48.6	56.2	53.2	53.1
Wind		-	-	0.2	18.2	63.8	73.4	88.3
Geothermal		-	-	-	0.0	-	-	-
Solar/other		-	3.4	3.6	11.9	71.1	94.2	119.5
TOTAL NET IMPORTS		**-454.5**	**-2790.1**	**-5462.9**	**-8000.2**	**-12972.2**	**-13271.8**	**-12499.9**
Coal	Exports	738.9	2816.3	5083.9	7971.3	10629.0	10504.9	9866.2
	Imports	-	-	-	1.8	17.0	19.3	12.4
	Net imports	-738.9	-2816.3	-5083.9	-7969.5	-10612.0	-10485.6	-9853.8
Oil	Exports	141.7	389.5	955.8	736.4	629.2	759.3	712.7
	Imports	527.4	602.8	1104.6	1592.5	2016.8	1906.8	1766.3
	Int'l marine and aviation bunker	-101.2	-88.8	-140.0	-170.9	-243.5	-190.7	-70.0
	Net imports	284.4	124.6	8.9	685.3	1144.1	956.7	983.6
Natural gas	Exports	-	98.4	387.9	876.0	3686.1	3904.7	3816.6
	Imports	-	-	-	160.0	181.8	161.8	186.8
	Net imports	-	-98.4	-387.9	-716.0	-3504.3	-3742.9	-3629.8
Electricity	Exports	-	-	-	-	-	-	-
	Imports	-	-	-	-	-	-	-
	Net imports	-	-	-	-	-	-	-
TOTAL STOCK CHANGES		**-3.1**	**-198.8**	**210.4**	**-252.7**	**-66.5**	**-70.4**	**98.3**
TOTAL SUPPLY (TES)[2]		**2388.9**	**3606.5**	**4526.2**	**5285.4**	**5617.4**	**5615.4**	**5453.1**
Coal		945.5	1460.7	2015.8	2113.1	1956.7	1782.6	1684.0
Peat		-	-	-	-	-	-	-
Oil		1113.0	1306.3	1429.9	1742.3	1840.0	1857.5	1777.4
Natural gas		141.6	619.2	807.0	1146.3	1422.8	1556.9	1529.8
Biofuels and waste[1]		147.7	165.9	210.8	205.0	206.9	197.7	200.9
Nuclear		-	-	-	-	-	-	-
Hydro		41.1	50.9	58.9	48.6	56.2	53.2	53.1
Wind		-	-	0.2	18.2	63.8	73.4	88.3
Geothermal		-	-	-	0.0	-	-	-
Solar/other		-	3.4	3.6	11.9	71.1	94.2	119.5
Electricity trade		-	-	-	-	-	-	-
Shares in TES (%)								
Coal		*39.6*	*40.5*	*44.5*	*40.0*	*34.8*	*31.7*	*30.9*
Peat		-	-	-	-	-	-	-
Oil		*46.6*	*36.2*	*31.6*	*33.0*	*32.8*	*33.1*	*32.6*
Natural gas		*5.9*	*17.2*	*17.8*	*21.7*	*25.3*	*27.7*	*28.1*
Biofuels and waste[1]		*6.2*	*4.6*	*4.7*	*3.9*	*3.7*	*3.5*	*3.7*
Nuclear		-	-	-	-	-	-	-
Hydro		*1.7*	*1.4*	*1.3*	*0.9*	*1.0*	*0.9*	*1.0*
Wind		-	-	-	*0.3*	*1.1*	*1.3*	*1.6*
Geothermal		-	-	-	*0.0*	-	-	-
Solar/other		-	*0.1*	*0.1*	*0.2*	*1.3*	*1.7*	*2.2*
Electricity trade		-	-	-	-	-	-	-

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Unit: PJ

DEMAND							
FINAL CONSUMPTION	**1973**	**1990**	**2000**	**2010**	**2019**	**2020**	**2021**
TFC	**1657.1**	**2372.1**	**2913.3**	**3222.7**	**3398.4**	**3296.5**	**3306.5**
Coal	217.6	190.8	175.8	106.3	119.9	111.9	113.4
Peat	-	-	-	-	-	-	-
Oil	1015.9	1214.1	1453.5	1653.4	1814.5	1717.4	1710.1
Natural gas	88.5	362.4	476.8	515.2	505.4	515.7	527.0
Biofuels and waste[1]	146.2	136.2	181.8	174.3	161.4	153.1	157.5
Geothermal	-	-	-	-	-	-	-
Solar/other	-	3.4	3.4	10.5	17.6	18.4	19.7
Electricity	188.9	465.2	621.9	763.1	779.5	780.0	779.0
Heat	-	-	-	-	-	-	-
Shares in TFC (%)							
Coal	*13.1*	*8.0*	*6.0*	*3.3*	*3.5*	*3.4*	*3.4*
Peat	-	-	-	-	-	-	-
Oil	*61.3*	*51.2*	*49.9*	*51.3*	*53.4*	*52.1*	*51.7*
Natural gas	*5.3*	*15.3*	*16.4*	*16.0*	*14.9*	*15.6*	*15.9*
Biofuels and waste[1]	*8.8*	*5.7*	*6.2*	*5.4*	*4.8*	*4.6*	*4.8*
Geothermal	-	-	-	-	-	-	-
Solar/other	-	*0.1*	*0.1*	*0.3*	*0.5*	*0.6*	*0.6*
Electricity	*11.4*	*19.6*	*21.3*	*23.7*	*22.9*	*23.7*	*23.6*
Heat	-	-	-	-	-	-	-
TOTAL INDUSTRY[3]	**745.8**	**974.4**	**1181.4**	**1153.3**	**1158.4**	**1152.4**	**1178.1**
Coal	205.0	179.3	169.3	101.6	119.3	111.1	113.1
Peat	-	-	-	-	-	-	-
Oil	332.3	267.8	319.6	309.4	348.5	354.4	357.4
Natural gas	62.5	252.3	312.2	329.0	301.6	306.4	318.6
Biofuels and waste[1]	62.5	62.1	103.0	110.7	107.9	101.1	106.2
Geothermal	-	-	-	-	-	-	-
Solar/other	-	-	-	-	-	-	-
Electricity	83.5	213.1	277.3	302.7	281.1	279.5	282.9
Heat	-	-	-	-	-	-	-
Shares in total industry (%)							
Coal	*27.5*	*18.4*	*14.3*	*8.8*	*10.3*	*9.6*	*9.6*
Peat	-	-	-	-	-	-	-
Oil	*44.6*	*27.5*	*27.0*	*26.8*	*30.1*	*30.7*	*30.3*
Natural gas	*8.4*	*25.9*	*26.4*	*28.5*	*26.0*	*26.6*	*27.0*
Biofuels and waste[1]	*8.4*	*6.4*	*8.7*	*9.6*	*9.3*	*8.8*	*9.0*
Geothermal	-	-	-	-	-	-	-
Solar/other	-	-	-	-	-	-	-
Electricity	*11.2*	*21.9*	*23.5*	*26.2*	*24.3*	*24.3*	*24.0*
Heat	-	-	-	-	-	-	-
TRANSPORT[2]	**541.4**	**883.9**	**1074.2**	**1256.0**	**1385.6**	**1291.6**	**1250.1**
OTHER[4]	**369.9**	**513.8**	**657.6**	**813.4**	**854.3**	**852.5**	**878.4**
Coal	11.8	8.5	2.8	0.8	0.6	0.8	0.2
Peat	-	-	-	-	-	-	-
Oil	145.5	72.5	84.6	124.7	127.7	117.9	147.6
Natural gas	25.9	109.7	151.9	173.6	184.4	190.2	190.5
Biofuels and waste[1]	83.7	74.1	78.7	56.6	48.2	47.6	47.6
Geothermal	-	-	-	-	-	-	-
Solar/other	-	3.4	3.4	10.5	17.6	18.4	19.7
Electricity	103.0	245.6	336.2	447.2	475.8	477.5	472.7
Heat	-	-	-	-	-	-	-
Shares in other (%)							
Coal	*3.2*	*1.7*	*0.4*	*0.1*	*0.1*	*0.1*	-
Peat	-	-	-	-	-	-	-
Oil	*39.3*	*14.1*	*12.9*	*15.3*	*14.9*	*13.8*	*16.8*
Natural gas	*7.0*	*21.3*	*23.1*	*21.3*	*21.6*	*22.3*	*21.7*
Biofuels and waste[1]	*22.6*	*14.4*	*12.0*	*7.0*	*5.6*	*5.6*	*5.4*
Geothermal	-	-	-	-	-	-	-
Solar/other	-	*0.7*	*0.5*	*1.3*	*2.1*	*2.2*	*2.2*
Electricity	*27.8*	*47.8*	*51.1*	*55.0*	*55.7*	*56.0*	*53.8*
Heat	-	-	-	-	-	-	-

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Unit: PJ

DEMAND							
ENERGY TRANSFORMATION AND LOSSES	**1973**	**1990**	**2000**	**2010**	**2019**	**2020**	**2021**
ELECTRICITY GENERATION[5]							
Input (PJ)	671.5	1474.8	2004.7	2529.8	2387.2	2334.5	2267.8
Output (PJ)	231.9	555.5	755.6	909.6	949.3	953.4	954.6
Output (TWh)	64.4	154.3	209.9	252.6	263.7	264.8	265.1
Output shares (%)							
Coal	*74.9*	*78.7*	*83.0*	*71.3*	*58.5*	*55.0*	*52.9*
Peat	-	-	-	-	-	-	-
Oil	*2.6*	*2.3*	*0.9*	*2.4*	*1.9*	*1.7*	*1.8*
Natural gas	*4.3*	*9.3*	*7.7*	*17.6*	*20.0*	*20.9*	*18.8*
Biofuels and waste [1]	*0.5*	*0.5*	*0.5*	*1.1*	*1.3*	*1.3*	*1.3*
Nuclear	-	-	-	-	-	-	-
Hydro	*17.7*	*9.2*	*7.8*	*5.3*	*5.9*	*5.6*	*5.6*
Wind	-	-	-	*2.0*	*6.7*	*7.7*	*9.3*
Geothermal	-	-	-	-	-	-	-
Solar/other	-	-	-	*0.2*	*5.6*	*7.9*	*10.5*
TOTAL LOSSES	**739.1**	**1226.1**	**1549.4**	**2060.7**	**2132.1**	**2098.7**	**2035.9**
of which:							
Electricity and heat generation[6]	439.6	917.1	1249.2	1620.4	1438.0	1381.3	1313.4
Other transformation	225.7	6.7	-101.1	-97.5	-80.2	-75.6	-58.9
Own use and transmission/distribution losses	73.8	302.4	401.3	537.8	774.3	793.1	781.4
Statistical differences	**-7.3**	**8.2**	**63.5**	**2.0**	**86.9**	**220.2**	**110.6**
INDICATORS	**1973**	**1990**	**2000**	**2010**	**2019**	**2020**	**2021**
GDP (billion 2015 USD)	339.14	569.05	794.24	1075.79	1356.74	1327.75	1392.89
Population (millions)	13.61	17.07	19.03	22.03	25.37	25.69	25.74
TES/GDP (MJ per 2015 USD)[7]	7.04	6.34	5.70	4.91	4.14	4.23	3.91
Energy production/TES	1.19	1.83	2.16	2.56	3.32	3.38	3.27
Per capita TES (GJ per capita)	175.47	211.34	237.86	239.90	221.46	218.56	211.87
Oil supply/GDP (MJ per 2015 USD)[7]	3.28	2.29	1.80	1.62	1.36	1.40	1.28
TFC/GDP (MJ per 2015 USD)[7]	4.89	4.17	3.67	2.99	2.50	2.48	2.37
Per capita TFC (GJ per capita)	121.72	139.00	153.09	146.27	133.97	128.30	128.47
CO_2 emissions from fuel combustion ($MtCO_2$)[8]	157.7	259.5	334.6	391.8	384.0	369.0	360.9
CO_2 emissions from bunkers ($MtCO_2$)[8]	6.0	2.2	3.0	2.2	2.5	2.2	1.3
GROWTH RATES (% per year)	**73-90**	**90-00**	**00-10**	**10-18**	**18-19**	**19-20**	**20-21**
TES	2.5	2.3	1.6	0.5	1.8	-0.0	-2.9
Coal	2.6	3.3	0.5	-1.1	1.4	-8.9	-5.5
Peat	-	-	-	-	-	-	-
Oil	0.9	0.9	2.0	0.7	-0.2	0.9	-4.3
Natural gas	9.1	2.7	3.6	2.2	4.4	9.4	-1.7
Biofuels and waste[1]	0.7	2.4	-0.3	0.8	-5.6	-4.5	1.6
Nuclear	-	-	-	-	-	-	-
Hydro	1.3	1.5	-1.9	2.0	-1.3	-5.4	-0.0
Wind	-	-	56.3	14.7	16.8	15.2	20.3
Geothermal	-	-	-	-100.0	-	-	-
Solar/other	-	0.4	12.9	20.4	35.5	32.5	26.8
TFC	2.1	2.1	1.0	0.8	-1.1	-3.0	0.3
Electricity consumption	5.4	2.9	2.1	0.2	0.7	0.1	-0.1
Energy production	5.1	4.0	3.3	3.3	6.3	1.6	-5.8
Net oil imports	-4.7	-23.2	54.5	8.0	-10.1	-16.4	2.8
GDP	3.1	3.4	3.1	2.7	2.0	-2.1	4.9
TES/GDP	-0.6	-1.1	-1.5	-2.1	-0.2	2.1	-7.4
TFC/GDP	-0.9	-1.3	-2.0	-1.8	-3.1	-0.8	-4.4

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Footnotes to energy balances

1 *Biofuels and waste* comprises solid biofuels, liquid biofuels, biogases and industrial waste. Data are often based on partial surveys and may not be comparable between countries.

2 Excludes international marine bunkers and international aviation bunkers.

3 *Industry* includes non-energy use.

4 *Other* includes residential, commercial and public services, agriculture/forestry, fishing, and other non-specified.

5 Inputs to electricity generation include inputs to electricity and co-generation plants. Output refers only to electricity generation.

6 Losses arising in the production of electricity and heat at main activity producer utilities and auto producers. For non-fossil-fuel electricity generation, theoretical losses are shown based on plant efficiencies of approximately 33% for solar thermal; 10% for geothermal; and 100% for hydro, wind and solar photovoltaic.

7 Toe per thousand US dollars at 2015 prices and exchange rates.

8 "CO_2 emissions from fuel combustion" have been estimated using the IPCC Tier I Sectoral Approach methodology from the 2006 IPCC Guidelines. Emissions from international marine and aviation bunkers are not included in national totals.

Statistical notes

- Unless otherwise noted, all GDP data are in USD 2015 prices and purchasing power parity (PPP).
- *Total energy supply (TES)* comprises production + imports – exports – international marine and aviation bunkers ± stock changes. This equals the total supply of energy consumed domestically, either in transformation (e.g. power generation and refining) or final use.
- *Total final consumption (TFC)* is the final consumption of energy (electricity, heat and fuels, such as natural gas and oil products) by end-users, not including the transformation sector (e.g. power generation and refining).
- *Total final energy consumption (TFEC)* excludes non-energy use which is counted in TFC. TFEC provides a more accurate assessment of the share of energy demand covered by renewable energy and is better aligned with the European Union's gross final energy consumption metric, which is used to set European Union member countries' renewable energy targets.
- The primary energy equivalent of nuclear electricity is calculated from the gross generation by assuming a 33% conversion efficiency. The calculation to be carried out is the following: gross electricity generation in TWh x 0.086/0.33 = primary energy equivalent in Mtoe.
- *Bioenergy* refers to solid and liquid biofuels, renewable waste and biogas and excludes non-renewable waste.
- *Buildings* includes the energy use of the residential sector (residential buildings) and commercial and public service sectors (service sector buildings).
- *Transport* excludes international aviation and navigation.
- *Industry* includes both energy and non-energy use of the industry sector, agriculture, forestry and fishing.
- *Non-energy use* refers to fuels used as raw materials and not used as fuel or transformed into another fuel. This typically comprises raw materials used in the chemical and petrochemical sector.
- *IEA30* is the equivalent of a weighted average of 30 IEA member countries.
- *CO_2 emissions from fuel combustion* have been estimated using the IPCC Tier I Sectoral Approach methodology from the 2006 IPCC Guidelines. Emissions from international marine and aviation bunkers are not included in national totals.

ANNEX C: International Energy Agency "Shared Goals"

The member countries* of the International Energy Agency (IEA) seek to create conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and to the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants. In order to secure their objectives, member countries therefore aim to create a policy framework consistent with the following goals:

1. Diversity, efficiency and flexibility within the energy sector are basic conditions for longer term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydropower, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases, this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3. The environmentally sustainable provision and use of energy are central to the achievement of these Shared Goals. Decision makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should respect the polluter-pays principle where practicable.

4. More environmentally acceptable energy sources need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA member countries wish to retain and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5. Improved energy efficiency can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle, from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued **research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7. Undistorted energy prices enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. Free and open trade and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. Co-operation among all energy market participants helps to improve information and understanding, and encourages the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA ministers at the meeting of 4 June 1993 in Paris, France.)

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Lithuania, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Türkiye, the United Kingdom and the United States.

ANNEX D: List of abbreviations

In this report, abbreviations and acronyms are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention, this glossary provides a quick and central reference for the abbreviations used.

Acronyms and abbreviations

ACCC	Australian Consumer and Competition Commission
ACCS	Australia's Carbon Crediting Scheme
ACCU	Australian Carbon Credit Unit
ACT	Australian Capital Territory
ADGSM	Australian Domestic Gas Security Mechanism
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AGIG	Australian Gas Infrastructure Group
APC	administered price cap
ARENA	Australian Renewable Energy Agency
AUD	Australian dollar. The average exchange rate in 2017 was 1.30 AUD = 1 USD.
BEV	battery electric vehicle
CAFE	Corporate Average Fuel Economy
CCA	Climate Change Authority
CCS	carbon capture and storage
CCUS	carbon capture, use and storage
CEFC	Clean Energy Finance Corporation
CEM	Clean Energy Ministerial
CER	Clean Energy Regulator
CMO	Critical Minerals Office
COP	Conference of the Parties
CRC	collaborative research centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCCEEW	Department of the Climate Change, Energy, the Environment and Water
DEF	diesel exhaust fluid
DER	distributed energy resources
DFAT	Department of Foreign Affairs and Trade
DISR	Department of Industry, Science and Resources
DR	demand response
DWGM	Declared Wholesale Gas Market
EC	European Commission
EITE	emissions-intensive trade-exposed

EMM	Energy Ministers Meeting
ERF	Emission Reduction Fund
ESB	Energy Security Board
ESG	environmental, social and governance
EU	European Union
EV	electric vehicle
FCAS	frequency control ancillary services
FID	final investment decision
FSSP	fuel security services payment
GDP	gross domestic product
GHG	greenhouse gas
ICE	internal combustion engine
IEA	International Energy Agency
ISP	Integrated System Plan
LFE	liquid fuel emergency
LNG	liquefied natural gas
LRET	Large-scale Renewable Energy Target
LULUCF	land-use, land use change and forestry
MSO	minimum stockholding obligation
NABERS	National Australian Built Environment Rating System
NatHERS	Nationwide House Energy Rating Scheme
NCC	National Construction Code
NDC	Nationally Determined Contribution
NEM	National Electricity Market
NEPP	National Energy Productivity Plan
NETP	National Energy Transformation Partnership
NGERS	National Greenhouse Gas and Energy Reporting Scheme
ODA	official development assistance
OECD	Organisation for Economic Co-operation and Development
PCF	Pan-Canadian Framework
PHEV	plug-in hybrid electric vehicle
PKGT	Port Kembla Gas Terminal
POFR	Petroleum and Other Fuels Reporting
PPA	power purchase agreement
PPP	purchasing power parity
PRRT	petroleum resource rent tax
PV	photovoltaics
R&D	research and development
RD&D	research, development and demonstration
RERT	Reliability and Emergency Reserve Trader
RET	renewable energy target

REZ	renewable energy zone
SME	small and medium-sized enterprise
SRES	scale renewable energy scheme
TCP	technology collaboration programme
TES	total energy supply
TFC	total final consumption
TFEC	total final energy consumption
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
USE	unserved energy
VRE	variable renewable energy

Units of measurement

bcm	billion cubic metres
b/d	barrels per day
CO_2	carbon dioxide
CO_2-eq	carbon dioxide equivalent
EJ	exajoule
g CO_2-eq	gramme of carbon dioxide equivalent
GJ	gigajoule
GW	gigawatt
GWh	gigawatt hour
kb/d	thousand barrels per day
kg CO_2-eq	kilogramme of carbon dioxide equivalent
kt	kilotonne
kWh	kilowatt hour
L	litre
m^2	square metre
mb	million barrels
MJ	megajoule
Mt	million tonnes
Mt CO_2	million tonnes of carbon dioxide
Mt CO_2-eq	million tonnes of carbon dioxide equivalent
MW	megawatt
MWh	megawatt hour
PJ	petajoule
t CO_2	tonne of carbon dioxide
TJ	terajoule
TWh	terawatt hour

International Energy Agency (IEA).

Unless otherwise indicated, all material presented in figures and tables is derived from IEA data and analysis.

We wish to acknowledge the traditional custodians of the land of the ACT Region where the in-depth review took place, the Ngunnawal people, and pay respect to their Elders, both past and present.

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Australia 2023

Energy Policy Review

The International Energy Agency (IEA) regularly conducts in-depth peer reviews of the energy policies of its member countries. This process supports energy policy development and encourages the exchange of international best practices and experiences to help drive secure and affordable clean energy transitions.

Since the IEA's last review in 2018, Australia has significantly raised its climate ambitions, with the 2022 Climate Change Act doubling the target for emissions reductions by 2030 and setting the goal of reaching net zero emissions by 2050.

To match these increased ambitions, Australia is seeking to update its existing strategies, starting with the preparation of a new emissions reduction plan for 2050. Emission reductions and energy efficiency improvement rates need to double by 2030, and further steps will be required to achieve the government's clean electricity target. Such efforts would support both climate and energy security goals.

To support its clean energy transition, Australia needs to strengthen its resilience to supply disruptions across all fuels, whether from climate change impacts or global energy price shocks. Flexibility, fuel availability and resilient infrastructure will become even more vital as Australia's energy system incorporates very high shares of variable renewables and is likely to face more frequent and more extreme weather events. Gas market reforms can help ensure energy security during the transition.

In this report, the IEA provides energy policy recommendations to help Australia effectively manage the transformation of its energy sector in line with its goals.