NDC ASPECTS

Country Report

Transition pathways for Australia

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Key messages

- Australia's per capita greenhouse gas (GHG) emissions decreased from 30.8 tCO_2e (carbon dioxide equivalents) in 2005 to 18.6 tCO_2e in 2022 by 60%, due to a significant decline in coal combustion and reduced emissions from Land Use, Land-Use Change and Forestry, which started to turn negative in 2016.
- The power sector was responsible for more than 49% of all energy related CO_2 emissions in 2022, followed by transport (about 24%), industry (20%) and buildings (7.3%).
- With the current Nationally Determined Contribution (NDC), Australia increased the 2030 target from 26%-28% GHG emission reduction compared to 2005 (published in 2015) to 43% (published in 2022). In Dec. 2023, the federal government stated, based on projections, that Australia is broadly on track to meet this target.
- Ambitious scenarios focus primarily on a transformation in mining and industry through new processes based on renewable energies (RES), the decarbonization of the electricity supply and efficiency measures and strategies for electrification in all areas of application (especially transport and buildings).
- The transformation in industry involves phasing out the mining of fossil fuels for domestic consumption and exports, ramping up the extraction of key raw materials for the energy transition and introducing a renewable energy supply in the basic materials industry.
- Improved standards and regulations are required in the building sector, as there is virtually no insulation and inefficient electrical air conditioning and heating systems are widespread.
- Australia's first fuel efficiency standard for vehicles is likely to enter into force 2025. But not as ambitious as the EU's CO_2 emission performance standards for cars and vans.
- The Integrated System Plan (ISP) outlines pathways for the electricity sector focusing on the required new transmission, generation, and storage across the National Electricity Market (NEM). The 2024 draft shows a coal phase-out by 2034 and a rapid uptake of renewables – mainly solar photovoltaics.

Introduction and overview

Australia has a population of around 26 million people and is one of the economically strong nations with a per capita GDP of over USD 65,000 PPP (2022), largely due to an abundance of raw materials. The country is the world's second largest coal and liquefied natural gas (LNG) exporter, especially to Northeast Asia, which has always been a key factor in the Australian economy and value creation. However, Australia also has enormous solar and wind energy potential to transform itself into a renewable continent and an exporter of renewable fuels, which would be an important factor in the transformation of its current fossil fuel customers[1].

The use of fossil fuels in the power sector, energy intensive industries and mining as well as transport are the main emission sources for energy-related CO_2. Total GHG emissions fell by 22% from 2005 to 2022, even though the population increased by 30% in the same period.

[1] Romain Zissler, REI, "Australia - The Giant Coal & LNG Exporter Turning into a Clean Energy Superpower", https://www.renewable-ei.org/en/activities/column/REupdate/20240605.php

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New policies and initiatives were introduced in 2022 after a change from a conservative to a Labor led government, and acceleration of deployment of renewables started already in 2023. In late 2023, the federal government released projections showing Australia is broadly on track to meet the current national target of cutting GHG emissions by 43 percent below 2005 levels by 2030. 'The federal government has been clear its 43% target was "*a floor, not a ceiling*"[2] (…). *We now have an important opportunity to build on current momentum to accelerate action this decade*', said Chris Bowen, Minister for Climate Change and Energy of Australia.'

Federal and state governments have started delivering a range of policies and initiatives to support the roll out of more renewable energy, increase the market for electric vehicles and accelerate the electrification of heating and cooking for residential and commercial buildings. The federal government will set the next 'Nationally Determined Contribution' under this agreement in 2025 with a new target for 2035, the reduction targets were still under discussion at the time of writing (June 2024).

Key topics in the climate debate

Renewable energies are expanding rapidly due to their favourable economics and over 30% of Australia's households use solar PV for residential electricity generation. Onshore wind generation is less popular and the permitting process has been very slow for many years. Between 2001 and 2005, it took around 9 years to get a construction permit. This 'lead time' for onshore wind projects dropped to around 2 ½ years between 2016 and 2020. The Labor government aims to reduce this time further to under 2 years[3].

The coal debate in Australia is clearly divided between domestic use and the export of thermal and coking coal. While the phase-out of coal for domestic electricity generation is planned for 2033/34 in Victoria and Queensland and for 2038 in New South Wales (NSW) and is accepted across all political parties, the phase-out of exported coal is extremely controversial. No political party in Australia – except the Greens – call for an end of coal exports. The Greens call for a stop of fossil fuel exports by 2030, but are hardly receiving any political support.

The export of renewable energy in form of hydrogen, synthetic fuels or as processed iron ore (Hot Briquetted Iron -HBI) is discussed under the scenario term 'Australia Renewable Energy Superpower'[4] and very popular. However, the implications on Australia's electricity demand – which is likely to triple if the plan is implemented – and the corresponding challenges for the expansion of the electricity system are not publicly discussed.

In the transport sector, the fuel efficiency standards for vehicles currently under discussion are controversial due to the popularity of large pick-up trucks (in Australia called UTE short for '*Utility vehicle*').

Australia's National Greenhouse Accounts include carbon emissions and post-fire sequestration associated with bushfires, based on satellite monitoring of fires across Australia. Bushfires release significant amounts of carbon dioxide, but generally recover over time, generating a significant carbon sink in the years following the fire. According to the Australian government (DCCEEW)[5], the 2019-20 bushfires will have negligible impact on Australia's progress towards its 2020 or 2030 target.

[2] Chris Bowen, Energy Minister of Australia, Annual Climate Change Statement to Parliament; https://minister.dcceew.gov.au/bowen/speeches/annual-climate-change-statement-parliament

[3] Australian National University (ANU), Renewable projects are getting built faster – but there's even more need for speed, 1st February 2024, https://iceds.anu.edu.au/news-events/news/renewable-projects-are-getting-built-faster-%E2%80%93-there%E2%80%99s-even-more-need-speed

[4] Chris Bowen, Energy Minister of Australia, July 2023, https://minister.dcceew.gov.au/bowen/speeches/speech-australia-renewable-energy-superpower-australian-embassy-japan

[5] Department of Climate Change, Energy, the Environment and Water; Estimating greenhouse gas emissions from bushfires in Australia's temperate forests: focus on 2019-20 (DCCEEW) https://www.dcceew.gov.au/climate-change/publications/estimating-greenhouse-gas-emissions-from-bushfires-in-australias-temperate-forests-focus-on-2019-20

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Key decarbonization pathways & related transformations

Despite Australia's commitment to reduce GHG emissions by 43% until 2030 based on 2005 levels, the Australian government does not have a clear roadmap for decarbonizing its economy and energy sector.

The Australian Energy Market Operator (AEMO) published the influential '*Integrated System Plan*' (ISP) which covers only the electricity sector in the National Electricity Market (NEM). It outlines the required new transmission lines, the possible development of new power generation and storage capacities over the next 10 years. The NEM is a wholesale market through which generators and retailers trade electricity. It interconnects the six eastern and southern states and territories and delivers around 80% of all electricity consumption in Australia[6].

Due to the lack of government-endorsed Paris-aligned energy scenarios and/or emission pathways, three scenarios are presented which have been published in early 2024. At time of writing these represent the most recent scenario publication. Furthermore, these scenarios are submitted as an input for the stakeholder engagement process for the ongoing ISP-2024 between February and April 2024. The final ISP 2024 plan is scheduled for the 28. June 2024. Furthermore, the scenarios are aimed to influence the NDC 2025 development to increase the GHG reduction target to 75% by 2035 (compared to 2005). They have been developed under the leadership of the Australian Climate Council[7] and the University of Technology Sydney (UTS)[8]. All scenarios assume a similar growth of population and GDP (see Table 1 in the Annex), the narratives are described in the following.

The 'Base Ambition' pathway (BA)

The ***Base Ambition*** pathway (*BA*) is based on the OECM 1.5 °C pathways for G20 countries[9] and takes international and national market and policy developments into account. Whereas the ambition for decarbonization is high, the main focus of this scenario is on the power sector. The development of demand in the transport sector is assumed to remain relatively stable, with moderate reductions in the overall passenger-kilometres and accelerated electrification rates in road transport. Decarbonization of the industry and building sectors follows the international best practice pathways developed under the OECM research project between 2017 and 2022[10] [11].

The 'Necessary Ambition' pathway (NP)

The ***Necessary Ambition*** pathway (*NP*) is based on the *BA* pathway but goes further, aiming to achieve an energy-related CO_2 reduction of 75% relative to 2005 by 2030. The main differences from the *BA* pathway are:

- accelerated implementation of solar photovoltaic, onshore and offshore wind installations;
- accelerated phase-out of oil and gas for residential and industrial process heating;
- accelerated shift to public transport and increase active transport modes—such as walking and cycling—in urban areas, to reduce car traffic, especially with internal combustion engines (ICEs).

[6] Australian Government, Department of Climate Change, Energy, the Environment and Water, website (viewed April 2024): https://www.dcceew.gov.au/energy/markets/national-electricity-market

[7] Climate Council, SEIZE THE DECADE: How we empower Australian communities and cut climate pollution 75% by 2030; Published by the Climate Council of Australia Limited. March 2024; https://www.climatecouncil.org.au/resources/seize-the-decade/

[8] Teske S., Rispler J., Miyake S. (2024) Australia: Aim High, Go Fast: Why Emissions Need to Plummet this Decade. Limiting global warming to 1.5 C.; Sectoral pathways & Key Performance Indicators for Net-Zero Target Setting Infrastructure Requirements for the National Electricity Market (NEM), Western Australian and the Northern Territory; prepared for the Climate Council by UTS-ISF; March 2024 https://www.uts.edu.au/oecm/australia

[9] Teske S. The 'Global Stocktake' and the remaining carbon budgets for G20 countries to limit global temperature rise to +1.5 °C. SN Applied Sciences 2023;5:256. https://doi.org/10.1007/s42452-023-05482-w

[10] Teske S, Niklas S, Talwar S (2022). Decarbonisation Pathways for Industries. In: Teske S. (ed.) Achieving the Paris Climate Agreement Goals. Springer, Cham. https://doi.org/10.1007/978-3-030-99177-7_5

[11] Chatterjee S, Kiss B, Ürge-Vorsatz D, Teske S (2022). Decarbonisation Pathways for Buildings. In: Teske S (ed.) Achieving the Paris Climate Agreement Goals. Springer, Cham. https://doi.org/10.1007/978-3-030-99177-7_7

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‘Necessary Ambition’ pathway plus ‘Renewable Energy Export’ (NPX)

The ***Necessary Ambition pathway plus Renewable Energy Export*** (*NPX*) is based on the *NP* scenario with the development of additional renewable energy exports for the steel and aluminium value chains. While the development of domestic energy demand between 2020 and 2050 is identical to that of the *NP* scenario, it is assumed that the iron ore and bauxite-mining industries switch to exporting HBI and alumina, respectively. The additional industrial processes will require a significant amount of additional electricity from 2035 onwards. All scenarios have higher GHG reduction ambition than Australia’s NDC submitted in 2021.

Summary – overall energy system and GHG emission pathway

Figure A shows the final energy demand per sector, gross power demand, and primary energy supply for the three calculated scenarios Basic Ambition (BA), Necessary Ambition (NP) and the Necessary Ambition plus Energy Export (NPX). The NPX leads to an extreme increase of final energy demand – mainly electricity – caused by energy related export goods such as hydrogen, HBI and alumina. All scenarios will lead to a total phase-out of fossil fuels. Solar energy will dominate Australia’s energy supply after 2030, but also wind will become a main pillar of the energy supply in 2050. Figure B shows the development of GHG emissions by sector and the relative CO_2 reduction in percent (left axis) to 2005. While the decrease of GHG emissions will be different in all three scenarios, all cases will lead to zero emissions by 2050. Figure B also shows the switch in LULUCF emissions from positive values to a carbon sink, but the contribution of this development to the compensation of remaining emissions is comparatively small.

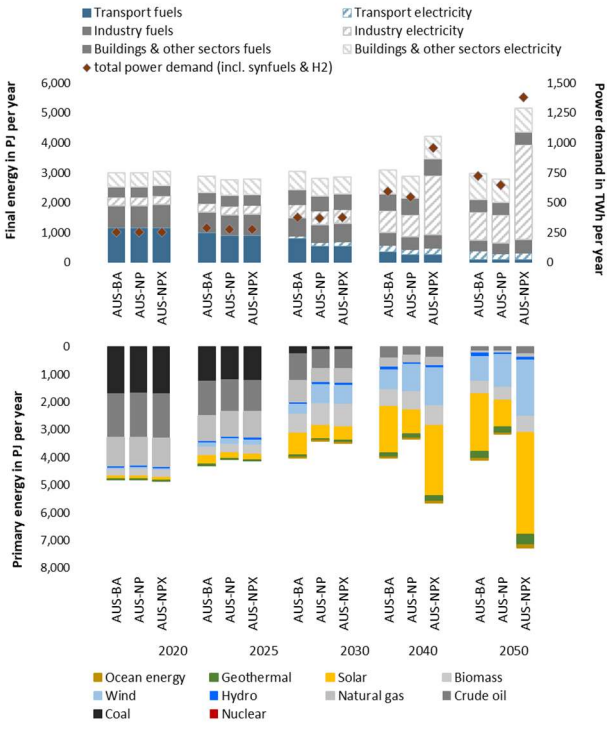

Figure A: Final energy demand per sector, gross power demand (upper panel), and primary energy supply, incl. non-energy use (bottom panel) in three scenarios

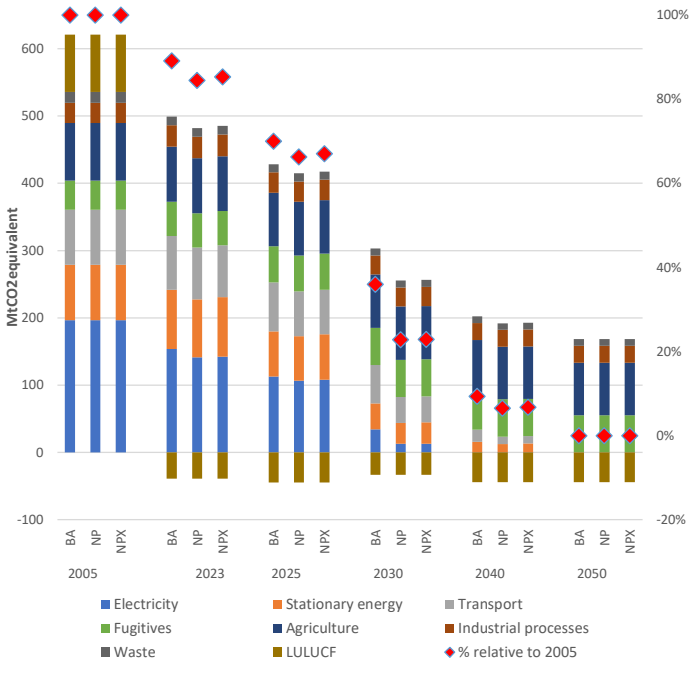

Figure B: Emission profile per sector and scenario: absolute GHG emissions (bars, left axis) and relative CO_2 reduction in percent compared to 2005 (red dots, right axis)

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Sectoral system transformations

In addition to the data for the sectoral system transformations provided in the annex, this section summarizes the key measures required to implement the 1.5˚C decarbonization pathway for the main sectors.

Industry

- Mining: Phase-out of thermal and coking coal mining and export of natural gas and transition to renewable based hydrogen and synthetic fuel production
- Iron & Steel: Start of renewable based processing of iron ore into hot briquetted iron (HBI) for export
- Aluminium and Bauxite: Start of renewable based processing of bauxite into alumina for export
- Increase of mining for lithium for batteries including battery production facilities
- Required re-training of workforce
- Utilization of Australia's fast solar, onshore and offshore wind resources
- Industry policy changes required as current policies support traditional industries

Transportation

- Implementation of a fuel efficiency standard for vehicles comparable to the European 'EURO 6' standard
- Improve charging network for electric vehicles outside metropolitan areas
- Improve public transport network in Australia's six capital cities in which over 65% of the population lives
- Build-up a secure and interconnected network of bicycles paths in metropolitan areas

Buildings

- Improved building standards and building codes. Australia's housing and commercial building stock is in an extremely poor condition with close to no insulation, mainly single glazing
- Inefficient electrical air conditioning and electrical heating systems are commonly used
- Effectiveness of insulation for buildings and residential homes is widely questioned in the public debate without awareness for optimized building envelops

Energy supply system

- Solar photovoltaic generators – both for roof-tops and utility scale are popular with significant growth rates
- Onshore wind power projects increased over the past year – but significantly behind the huge potential
- Offshore wind development started in 2019 – first permit in 2024. First grid connected project estimated just before 2030
- Nuclear and CCS does not play a role in the current energy industry – used in the public debate mainly from opposition leaders to delay renewable energy projects
- Australia's potential for solar and wind energy is one of the largest in the world[12]

[12] Further information: https://www.uts.edu.au/oecm/renewable-resource-mapping

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AFOLU

- Refine, scale and incentivise uptake of agricultural feed additives and viable delivery models
- End native forest logging and address deforestation
- Incentivise active restoration of land
- Roll out food and garden waste services right around Australia

Global conditions

The five largest Australian industry sectors that contributed almost half of the national GDP at the beginning of 2024 were mining (14.3%), health & education (12.8%), finance (7.4%), construction (7.1%) and manufacturing (5.7%)[13]. Mining is almost entirely dependent on global commodity prices. The increasing demand for metals for electronics and energy infrastructure as well as the required phase-out of fossil fuels – especially coal and natural gas – significantly impact the domestic policy debate.

In contrast, the construction sector is influenced by domestic market development and policies. Australia has an affordable living crisis due to extensive (financial) speculation with real estate – especially residential buildings. The quality of the building stock itself is extremely poor to widen profit margin for market participants even further. Even basic energy standards are not met as cheapest materials are used to lower construction costs further. Effective policies to avoid real estate speculation, decrease the costs of living and reduce operation costs – especially energy – are not in place.

While Australia's manufacturing industry is relatively small, international policy mechanisms such as the Carbon Border Adjustment Mechanism (CBAM) of the European Union or the Inflation Reduction Act (IRA) have limited effect on Australia's economy. However, the mining industry discusses possible indirect effects.

Australia has among the largest renewable energy potential – especially solar and wind energy – globally. Very good solar radiation and high average wind speeds – both onshore and offshore – in combination with access to land for utility scale projects lead to attractive conditions for project developers. This also leads to promising potential for the development of export routes for green fuels, particularly to the Northeast Asian economic regions. However, the shortage of qualified labour and a very low local production capacities pose major challenges for the rapid expansion of the renewable energy industry.

Key messages for next NDCs

Australia has last updated its NDC in 2022 after a change in government from Liberal to Labor. The new government increased climate ambition significantly and ended an almost decade long absence of any coordinated energy policies. Renewable energy installation surged since 2022 significantly. The following section summarizes the 2022 NDC submission. A new submission is planned for 2025, but the debates are still in a very early stage and mainly focused on renewable energy expansion, grid infrastructure and vehicle efficiency standards.

[13] Reserve Bank of Australia, February 2024; https://www.rba.gov.au/education/resources/snapshots/economy-composition-snapshot/

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Summary NDC 2022

Australia raises the ambition of the 2030 target, committing to reduce GHG emissions by 43% below 2005 levels by 2030. In 2015, the target was 15 percentage point lower: 26-28% GHG emissions reduction by 2030 (based on 2005 levels). The revised 2030 commitment is both a single-year target and a multi-year emissions budget from 2021-2030. Australia also reaffirmed its target to achieve net zero emissions by 2050. Both targets are economy-wide emissions reduction commitments, covering all sectors and gases included in Australia's national inventory. Furthermore, it was decided that Australia will not carry over any overachievement on the 2020 target or Kyoto Protocol targets to meet its Paris Agreement targets as discussed from the previous government. The 2022 NDC includes the following new policies for Australia:

- A $20 billion investment in Australia's electricity grid
- A $300 million budget to deliver community batteries and solar banks across Australia
- Investment of up to $3 billion from the new National Reconstruction Fund to support renewables manufacturing and the deployment of low emissions technologies
- The Powering the Regions Fund to support the development of new clean energy industries and the decarbonisation priorities of existing industry
- The fund will prioritise building the workforce skills required for the energy transition
- A further $100 million budget to train 10,000 New Energy Apprentices
- A $10 million New Energy Skills Program to provide additional training pathways
- The introduction of declining emissions baselines for major emitters, under the existing Safeguard Mechanism, providing a predictable policy framework for industry, consistent with a national trajectory to net zero and supporting international competitiveness
- A (first) National Electric Vehicle Strategy, and a $500 million '*Driving the Nation*' fund to accelerate investment in charging and refuelling infrastructure
- *"Electric car tax'* discount and the first fuel efficiency standard for vehicles
- A commitment to reduce the emissions of Commonwealth Government agencies to net zero by 2030 (excluding defence and security age)
- The Australian Government will introduce a new annual statement to Parliament on climate policy, progress against national targets and international developments under the leadership of the Australian Climate Change Authority
- Australia is committed – in cooperation with Pacific Island States – to jointly hosting a future UNFCCC Conference of the Parties meeting (most likely COP31)

Lessons learned

Decarbonization of the electricity sector is successful and the least controversial topic. Decarbonization of the mining industry – especially for coal and gas export – is highly controversial and was not successful over the past decade. Furthermore, the introduction of small and efficient vehicles and electric vehicles failed largely of the past decade, but gets some traction since large electric vehicles are available on the market – especially in Australia's metropolitan areas. The main challenge in Australia is to maintain political support for the successful energy transition measures implemented by the federal Labor government under Anthony Albanese since 2022. New natural gas and coal mining projects for export remain controversial and policies are not in line with a 1.5°C target.

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Annex

Key socio-economic figures

Table 1 shows the population growth and the long-term GDP development of an average of 1.05% per year until 2050 – the outlook is based on the Australian Government projection.

Table 1: Australia—population and economic development 2019–2050

	Unit	2019	2020	2025	2030	2035	2040	2045	2050
Population	[million]	25.4	25.7	27.4	29.1	30.5	31.7	32.7	33.6
GDP USD	[billion]	1,491	1,327	1,717	1,991	2,308	2,637	2,940	3,151
GDP growth	[%/yr]	2.1%	-4.61%	3.0%	3.0%	3.0%	2.5%	2.0%	1.0%

Source: Australian Bureau of Statistics, https://www.abs.gov.au/statistics

Current emission situation

Australia's greenhouse gas (GHG) emissions without Land Use, Land-Use Change and Forestry (LULUCF) rose slightly by up to 5% in total between 2005 and 2019, but have been lower again since 2021 than in 2005.

Table 2: Australia—overview current GHG emissions

	2005			2022		
	Annual total [Mt CO_2e]	GHG shares [%]	Annual per capita [tCO_2e]	Annual total [Mt CO_2e]	GHG shares [%]	Annual per capita [tCO_2e]
Electricity	197	32%	9.7	158	32%	6.0
Stationary energy	82	13%	4.1	103	21%	3.9
Transport	82	13%	4.1	91	19%	3.5
Total energy-related CO_2 emissions	**361**	**58%**	**17.9**	**351**	**72%**	**13.4**
relative to 2005	-	-	-	*-3%*	*+24%*	*-25%*
Fugitives	43	7%	2.1	50	10%	1.9
Agriculture	86	14%	4.3	80	16%	3.0
Industrial processes	30	5%	1.5	32	7%	1.2
Waste	16	3%	0.8	13	3%	0.5
LULUCF	85	14%	4.2	-39	-8%	-1.5
Total GHG emissions	**621**	**100%**	**30.8**	**487**	**100%**	**18.6**
relative to 2005	-	-	-	*-22%*	-	*-40%*
Population	**20.17 million**			**26.18 million**		

Source: DCCEEW, Statistics 2023

The electricity related CO_2 emissions are declining due to significant increase of renewable energy – especially solar photovoltaics (PV). Australia's power sector was dominated by hard and brown coal supplying over 70% of the electricity for decades. By 2019, the generation share dropped for the first time just under 60% in 2019 decreasing further to 56% in 2020. By 2022 the share of coal dropped to 49.2%[14], while renewables increase their share to 30.8%. Solar and wind power generation increased by 267% between 2000 and 2022. While the trend in power generation goes in the right direction, emissions from buildings and industry – in Australia both sectors are lumped together under the term 'Stationary energy' – have increased since 2005[15]. Furthermore, the transport emissions

[14] IEA country analysis: https://www.iea.org/countries/australia/coal
[15] Australia used the base year 2005 for emission benchmarks

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have increased significantly, due to the very large and inefficient SUVs which are commonly used through-out the country. Since 2016, LULUCF emissions have started to be negative, i.e. the sector is becoming a carbon sink again.

Key scenario data for Australia

Table 3: Industry sector—market development and energy intensities

Industry Sector	Unit	2019	2020	2025	2030	2035	2040	2045	2050
Chemical Industry									
Market Chemical Industry	[bn $GDP]	11.6	11.9	13.7	15.9	18.5	21.1	23.5	25.2
Average growth rate	[%/yr]		0%	3%	3%	4%	4%	4%	4%
Chemical Industries—average energy intensity	[MJ/$GDP]	4.31	4.24	4.05	4.01	3.97	3.93	3.89	3.85
Steel Industry									
Regional: Mining iron ore—production volume	[Mt/yr]	919	912	940	992	1,059	1,129	1,217	1,311
Annual production volume—Iron & Steel Industry	[Mt/yr]	5.4	5.5	5.7	6.0	6.4	6.8	7.3	7.9
Primary steel production—share of total production	[%]	79%	79%	69%	64%	59%	56%	54%	52%
Secondary/scrap steel—share of total production	[%]	21%	21%	31%	36%	41%	44%	46%	48%
Average Energy Intensity: Steel Production	[GJ/ton]	12.1	12.1	11.7	11.3	11.9	11.1	11.1	10.8
Energy Intensity—PRIMARY steel (FINAL ENERGY)	[GJ/ton]	14.1	14.1	14.1	14.1	13.3	12.2	11.6	10.9
Energy Intensity—SECONDARY steel (FINAL ENERGY)	[GJ/ton]	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Aluminium Industry									
Mining bauxite—production volume	[Mt/yr]	105	104	111	122	132	143	154	165
Annual production volume—aluminium Industry	[Mt/yr]	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7
Primary aluminium production—share of total production	[%]	99%	99%	63%	59%	57%	54%	50%	48%
Secondary/scrap aluminium—share of total production	[%]	1%	1%	37%	41%	43%	46%	50%	52%
Bauxite Mining—Energy Intensity	[PJ/Mt]	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6
Primary Aluminium—Energy intensity - Electricity (Anode, Electrolysis + Ingot)	[PJ/Mt]	55.8	55.8	54.4	53.1	51.7	50.4	49.2	47.9
Secondary Aluminium—Energy intensity - Electricity (Anode, Electrolysis + Ingot)	[PJ/Mt]	2.8	2.8	2.7	2.7	2.6	2.5	2.5	2.4
Cement Industry									
Cement—production volume	[Mt/yr]	10	11	12	12	12	12	13	13
Clinker—production volume (based on clinker to cement ratio)	[Mt/yr]	8.3	9.2	8.9	8.3	8.1	8.0	7.8	7.7
Thermal energy intensity—per tonne of clinker	[GJ/ton]	3.5	3.5	3.4	3.3	3.3	3.2	3.2	3.1
Cement production—electricity intensity	[kWh/ton]	116	116	103	87	85	83	81	79
Thermal energy intensity—per tonne of cement (final energy)	[GJ/ton]	5.2	4.7	4.0	3.5	3.0	2.1	2.0	2.0
Product energy intensity (thermal + electricity)—per tonne of cement (final energy)	[GJ/ton]	5.6	5.1	4.4	3.8	3.3	2.4	2.3	2.3
Textile & Leather Industries									
Textile Industries—Economic value	[bn $GDP]	0.5	0.5	1.2	1.4	1.6	1.9	2.1	2.2
Leather Industry—Economic value	[bn $GDP]	0.6	0.6	0.8	0.9	1.1	1.3	1.4	1.5
Total Textile & Leather	[bn $GDP]	1.1	1.1	2.0	2.4	2.7	3.1	3.5	3.7
Textile Mills—Energy Intensities	[MJ/$GDP]	4.53	4.53	4.42	4.31	4.20	4.09	3.99	3.89
Textile Products Mills—Energy Intensities	[MJ/$GDP]	4.58	4.58	4.47	4.35	4.25	4.14	4.04	3.94
Clothing Industries—Energy Intensities	[MJ/$GDP]	0.86	0.86	0.84	0.82	0.80	0.78	0.76	0.74
Textile Industry—Average Energy Intensity	[MJ/$GDP]	4.37	4.37	4.26	4.15	4.05	3.95	3.85	3.75
Leather and Allied Products Industries—Energy Intensity	[MJ/$GDP]	1.49	1.49	1.45	1.42	1.38	1.35	1.31	1.28

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Table 4: Service sector—market development and energy intensities

Services	Unit	2019	2020	2025	2030	2035	2040	2045	2050
Water Utilities									
Water withdrawal—total	[billion m^3]	16	16	16	16	18	19	21	22
- saltwater component	[billion m^3]	0	0	0	0	0	1	1	1
Saltwater share (of total water withdrawal)	[%]	0%	0%	1%	2%	3%	3%	3%	4%
Agricultural water	[billion m^3]]	10	10	10	10	12	12	13	14
Municipal water	[billion m^3]	3	3	3	3	4	4	4	4
Industrial water	[billion m^3]	3	3	3	3	3	3	3	3
Water Utilities Energy Intensities									
Water Pumping & Distribution	[kWh/m^3]	0.18	0.18	0.18	0.18	0.18	0.18	0.17	0.17
Desalination	[kWh/m^3]	4.50	4.50	4.44	4.39	4.33	4.28	4.23	4.17
Wastewater Treatment	[kWh/m^3]	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05
Average Electricity Intensity (across all processes)	[kWh/m^3]	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Average Heat Intensity (across all processes)	[MJ/m^3]	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Agriculture									
Agriculture—Economic Value	[bn $]	33	33	38	44	51	59	65	70
Food & Processing Industry—Economic Value	[bn $]	35	35	41	48	55	63	70	75
Tobacco Industry—Economic Value	[bn $]	2	2	2	3	3	3	4	4
Average Energy Intensity: Agriculture & Food Processing	[MJ/$GDP]	3.49	3.49	3.44	3.40	3.36	3.31	3.27	3.23
Tobacco Products Industries	[MJ/$GDP]	0.40	0.40	0.40	0.39	0.39	0.38	0.38	0.37
Forestry & Wood									
Forestry Industry—Economic Value	[bn $]	6.1	6.1	7.1	8.2	9.6	10.9	12.2	13.1
Wood - Industry—Economic Value	[bn $]	7.1	7.1	8.4	9.7	11.3	12.9	14.4	15.4
Pulp & Paper Industry—Economic Value	[bn $]	5.8	5.8	6.9	8.0	9.2	10.5	11.8	12.6
Forestry—total	[MJ/$GDP]	3.38	3.38	3.34	3.30	3.25	3.21	3.17	3.13
Wood Products Industries	[MJ/$GDP]	16.46	16.46	16.25	16.05	15.85	15.65	15.46	15.26
Pulp Mills	[MJ/$GDP]	269	269	266	262	259	256	253	249
Paperboard Mills	[MJ/$GDP]	67	67	66	65	64	64	63	62
Average Energy Intensity: Forestry, Wood and Paper Industry	[MJ/$GDP]	4	4	3	3	3	3	3	3

Table 5: Building stock—development and energy intensities

Buildings	Unit	2019	2020	2025	2030	2035	2040	2045	2050
Building Stock: Residential	[billion m^2]	1.9	2.5	4.0	6.2	7.1	7.2	7.2	1.9
Building Stock: Commercial	[billion m^2]	0.7	0.8	1.2	1.8	2.1	2.1	2.3	0.7
Residential Buildings: Energy Intensity	[kWh/m^2]	138	138	134	126	118	110	101	93
Commercial Buildings: Energy Intensity	[kWh/m^2]	88	88	84	77	71	65	61	57
Construction: Residential and Commercial Buildings—Energy Intensity	[MJ/$GDP]	0.70	0.70	0.67	0.66	0.66	0.65	0.64	0.64
Residential Buildings: Total Emissions Intensity (Heating & Electricity)	[$kgCO_2$/kWh]	0.89	0.87	0.51	0.13	0.03	0.01	0.00	0.00
Residential Buildings: Emissions Intensity—Heat per square metre	[$kgCO_2/m^2$]	19.5	18.4	13.8	4.4	2.5	1.4	0.3	0.0
Residential Buildings: Emissions Intensity—Heat	[$kgCO_2$/kWh]	0.141	0.133	0.103	0.035	0.021	0.013	0.003	0.000
Residential Buildings: Emissions Intensity—Electricity	[$kgCO_2$/kWh]	0.748	0.734	0.405	0.097	0.007	0.000	0.000	0.000
Commercial Buildings: Total Emissions Intensity (Heating & Electricity)	[$kgCO_2$/kWh]	29.17	27.50	21.06	7.00	4.07	2.33	0.63	0.00
Commercial Buildings: Emissions Intensity—Heat per square metre	[$kgCO_2/m^2$]	28.8	27.2	20.8	6.9	4.0	2.3	0.6	0.0
Commercial Buildings: Emissions Intensity—Heat	[$kgCO_2$/kWh]	0.328	0.310	0.248	0.089	0.056	0.035	0.010	0.000
Commercial Buildings: Emissions Intensity—Electricity	[$kgCO_2$/kWh]	0.748	0.734	0.405	0.097	0.007	0.000	0.000	0.000

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Table 6: Transport sector—energy intensities

Total Transport Sector	Unit	2019	2020	2025	2030	2035	2040	2045	2050
Aviation Passenger: Energy Intensity	[MJ/pkm]	5.81	5.81	4.83	4.51	4.39	4.28	4.23	4.18
Aviation Freight: Energy Intensity	[MJ/tkm]	32.20	32.20	29.12	27.16	26.46	25.76	25.48	25.20
Shipping Passenger: Energy Intensity	[MJ/pkm]	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05
Shipping Freight: Energy Intensity	[MJ/tkm]	0.20	0.20	0.19	0.18	0.18	0.18	0.17	0.17
Road Passenger: Energy Intensity	[MJ/pkm]	2.49	2.64	1.82	1.53	0.98	0.87	0.63	0.43
Road Freight: Energy Intensity	[MJ/tkm]	1.34	1.34	1.17	1.08	0.86	0.79	0.59	0.58

Table 7: Transport sector—assumed development of passenger–kilometres (Pkm)

Pkm [million pkm/yr]	2020		2025		2030		2040		2050	
	BA	NP	BA	NP	BA	NP	BA	NP	BA	NP
Aviation	55,708	55,708	72,255	72,255	65,313	65,313	50,697	50,697	37,385	37,385
Rail	15,139	15,139	25,279	27,812	40,035	63,563	64,493	99,592	89,056	100,527
Road	295,158	295,158	263,911	258,525	257,313	245,599	244,608	216,986	232,531	191,707
Passenger cars	277,449	277,449	248,076	243,013	238,014	221,039	214,032	189,863	197,651	153,366
Buses	17,710	17,710	15,835	15,511	19,298	24,560	30,576	27,123	34,880	38,341
Bus pkm in % (BITRE data 2020)	6%	6%	6%	6%	8%	10%	13%	13%	15%	20%
Active transport (increase from 2022)	0	0	2,533	5,065	14,756	19,251	11,456	22,206	5,336	23,371
Active transport per person and day in km	0	0	0	1	1	2	1	2	1	2

Table 8: Electricity generation structure in Australia in the scenario 'Necessary Ambition' pathway (NP)

Electricity generation [TWh/yr]	2019	2020	2025	2030	2035	2040	2045	2050
Total generation	258	253	275	369	476	546	606	645
- Fossil	208	196	147	22	2	0	0	0
- Hard coal (& non-renewable waste)	72	65	85	0	0	0	0	0
- Lignite	82	77	16	0	0	0	0	0
- Gas	53	53	45	21	1	0	0	0
- Oil	1	1	1	1	1	0	0	0
- Hydrogen	0	0	0	2	5	5	6	6
- of which renewable H_2	0	0	0	0	0	0	0	0
- Renewables (w/o renewable hydrogen)	50	57	128	347	474	545	606	645
- Hydro	16	16	21	23	23	22	23	22
- Wind	18	17	54	193	258	293	332	360
- PV	15	20	45	112	166	195	210	213
- Biomass (& renewable waste)	2	3	5	9	9	9	9	9
- Geothermal	0	0	3	7	11	18	23	30
- Solar thermal power plants	0	0	1	1	1	2	2	2
- Ocean energy	0	0	0	1	1	2	2	2
Distribution losses	13	13	14	18	23	25	26	26
Own consumption electricity	30	30	27	32	34	32	32	34
Electricity for hydrogen production	0	0	1	5	15	27	39	48
Electricity for synfuel production	0	0	0	0	3	7	8	7
Final energy consumption (electricity)	216	210	233	313	401	455	500	529
Variable RES (PV, Wind, Ocean)	33	38	99	306	425	490	544	575
RES share (domestic generation)	19%	22%	47%	94%	100%	100%	100%	100%

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Table 9: Final energy demand in Australia by sector in the scenario 'Necessary Ambition' pathway (NP)

Final Energy Demand [PJ/yr]	2019	2020	2025	2030	2035	2040	2045	2050
Total (incl. non-energy use)	3.416	3.179	2.935	2.985	3.084	3.095	3.016	3.004
Total energy use (excl. non-energy use)	3.194	2.999	2.764	2.802	2.883	2.884	2.803	2.790
Transport	1.417	1.188	928	662	516	439	336	279
- Oil products	1.374	1.162	881	513	264	148	25	0
- Natural gas	3	2	1	0	0	0	0	0
- Biofuels	5	4	13	33	73	88	72	49
- Synfuels	0	0	0	1	9	24	30	27
- Electricity	23	21	33	114	165	173	199	189
RES electricity	4	5	15	107	164	173	199	189
- Hydrogen	0	0	1	1	5	6	11	14
RES share Transport	1%	1%	3%	21%	49%	66%	93%	100%
Industry	917	997	954	1.065	1.119	1.160	1.249	1.321
- Electricity	271	285	298	453	602	743	847	938
RES electricity	52	64	139	427	600	742	847	938
- Public district heat	0	0	0	0	0	0	0	0
- Hard coal & lignite	129	143	128	84	46	0	0	0
- Oil products	158	176	38	24	7	0	0	0
- Gas	254	278	329	191	172	138	73	0
- Solar	0	0	25	48	59	67	82	96
- Biomass	104	115	126	242	187	130	128	154
- Geothermal	0	1	9	16	28	36	47	57
- Hydrogen	0	0	1	6	17	46	73	76
RES share Industry	17%	18%	31%	69%	80%	88%	94%	100%
Other Sectors (residential, commercial…)	860	814	881	1.075	1.247	1.284	1.218	1.189
- Electricity	476	462	518	568	682	725	754	777
RES electricity	92	104	241	535	680	725	754	777
- Public district heat	0	0	0	0	0	0	0	0
- Oil products	113	102	87	0	0	0	0	0
- Gas	207	190	162	64	73	48	27	0
- Solar	16	14	19	39	79	100	101	119
- Biomass	48	47	71	388	381	361	273	194
- Geothermal	0	0	8	17	32	50	62	82
- Hydrogen	0	0	0	0	0	0	0	18
RES share Other Sectors	18%	20%	38%	91%	94%	96%	98%	100%
Total RES	322	352	667	1.860	2.314	2.550	2.678	2.790
RES share	10%	12%	24%	66%	80%	88%	96%	100%
Non-energy use	222	181	172	183	202	211	213	215
- Oil	174	134	127	135	148	154	155	156
- Gas	47	47	45	48	53	56	57	58
- Coal	0	0	0	0	0	0	0	0

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Table 10: Primary energy demand in Australia in the scenario 'Necessary Ambition' pathway (NP)

Primary Energy Demand [PJ/yr]	2019	2020	2025	2030	2035	2040	2045	2050
Total (incl. non-energy-use)	5,060	4,777	4,075	3,392	3,381	3,308	3,178	3,147
- Fossil (excluding on-energy use)	4,441	4,134	3,090	1,107	621	358	127	0
- Hard coal	815	766	965	94	52	0	0	0
- Lignite	916	908	216	0	0	0	0	0
- Natural gas	1,035	993	885	454	275	200	102	0
- Crude oil	1,674	1,467	1,023	558	294	158	25	0
- Nuclear	0	0	0	0	0	0	0	0
- Renewables	397	463	814	2,102	2,558	2,739	2,839	2,932
- Hydro	56	56	77	81	83	80	82	80
- Wind	64	63	192	683	894	989	1,101	1,182
- Solar	69	87	209	492	730	854	914	950
- Biomass	208	256	309	784	746	659	545	465
- Geothermal	0	1	26	58	101	151	191	247
- Ocean energy	0	0	0	3	4	6	7	9
RES share	8%	10%	21%	66%	80%	88%	96%	100%

Table 11: Energy-related CO_2 emissions in Australia in the scenario 'Necessary Ambition' pathway (NP)

Energy-related CO_2 emissions [million tons/yr]	2020	2025	2030	2035	2040	2045	2050
Power plants (incl. cogeneration in Industry and Other sectors)	183	111	11	1	0	0	0
- Hard coal (& non-renewable waste)	64	71	0	0	0	0	0
- Lignite	85	17	0	0	0	0	0
- Gas	33	23	10	1	0	0	0
- Oil + Diesel	1	1	1	0	0	0	0
CO_2 emissions by sector	343	239	82	43	24	8	0
- Industry	69	48	26	17	8	4	0
- Other sectors	22	19	5	5	4	2	0
- Transport	79	66	38	20	11	2	0
- Power generation (public plants only)	174	107	13	0	0	0	0
- Other conversion	6	5	2	1	1	0	0

Table 12: Installed power generation capacities in Australia in the scenario 'Necessary Ambition' pathway (NP)

Installed capacity [GW]	2020	2025	2030	2035	2040	2045	2050
Total generation capacities	81.6	104.9	172.4	219.9	244.4	259.5	268.5
- Fossil	43.7	33.9	13.6	0.5	0.1	0.0	0.0
- Hard coal (& non-renewable waste)	14.0	13.1	0.0	0.0	0.0	0.0	0.0
- Lignite	15.4	3.2	0.0	0.0	0.0	0.0	0.0
- Gas (w/o hydrogen)	14.2	12.9	12.9	0.0	0.0	0.0	0.0
- Oil & Diesel	1.1	0.7	0.7	0.5	0.1	0.0	0.0
- Hydrogen (fuel cells, gas power plants incl. cogeneration)	0.0	0.1	0.6	1.5	1.8	1.9	2.0
- Renewables	37.9	70.8	158.2	217.9	242.5	257.6	266.5
- Hydro	5.6	6.4	6.7	6.8	6.5	6.6	7.4
- Wind	8.3	17.4	68.6	87.7	95.1	103.8	108.7
of which wind offshore	0.0	0.1	5.3	9.1	13.9	17.2	19.8
- PV	21.3	44.9	78.8	118.5	134.8	140.0	141.9
- Biomass (& renewable waste)	1.5	1.6	2.4	2.2	2.1	2.1	2.2
- Geothermal	1.0	0.4	1.0	1.6	2.5	3.1	4.1
- Solar thermal power plants	0.0	0.2	0.3	0.5	0.7	0.9	1.1
- Ocean energy	0.0	0.0	0.4	0.6	0.8	1.1	1.3
RES share generation capacities	46%	68%	92%	99%	99%	99%	100%

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COUNTRY REPORT

Transition pathways for Australia

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