Climate Action Tracker

Scaling up climate action

Key opportunities for transitioning to a zero emissions society

EXECUTIVE SUMMARY

CAT Scaling Up Climate Action series

AUSTRALIA

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CLIMATE ANALYTICS

CAT Scaling Up Climate Action series

The Climate Action Tracker (CAT) strives to support the enhancing of climate action in the context of the Paris Agreement implementation. This analysis contributes to revisions of mitigation targets, and aims at spurring an increase in climate mitigation actions, to close the gap between current emissions projections and required Paris-compatible pathways.

As part of this, we have been researching the potential for countries to scale up climate action in different focus areas. The analysis in this report is relevant to governments considering revisions to their Nationally Determined Contributions (NDCs) to be submitted under the Paris Agreement by 2020, and also to their submission of long-term low greenhouse gas development plans, also due by 2020.

The result is our **Scaling Up Climate Action** country series, which identifies options for increased sectoral action that would move a country towards a pathway compatible with the Paris Agreement's long-term temperature limit and estimates the impact of those actions on emissions and other benefits.

The first round of our analysis covers **South Africa**, the **European Union**, **Argentina**, **Indonesia**, **Turkey**, and **Australia**.

The consistent method and similar structure for all six reports allows for country-specific insights, while enabling a cross-country comparison to draw general research findings and lessons learnt on global potentials.

climateactiontracker.org/publications/scalingup

Executive summary

Introduction and objectives

Under the Paris Agreement, governments have committed to holding temperature increase well below 2°C above pre-industrial levels and pursuing efforts to limit it to 1.5°C. According to Climate Action Tracker (CAT) estimates, emission reduction targets put forward by governments in aggregate will, even if fully implemented, fall short and will lead to an estimated warming of around 2.9°C globally by 2100.

The 1.5°C limit in the Paris Agreement is of critical importance for Australia. The continent is highly exposed to climate change impacts like sea level rise, coral reef loss, wildfires and extreme weather events. All of these effects can already be observed today and will be much worse in a 2°C world, compared to 1.5°C. Especially for tropical coral reefs, including the Great Barrier Reef, the difference between 1.5°C and 2°C is likely to be decisive if any reefs are to survive.

To stay below the globally-agreed limit, the IPCC Special Report on 1.5°C (SR15) finds that a massive increase in effort is required to peak global GHG emissions as soon as possible, reduce total global greenhouse gas emissions, including CO_2 emissions, to 45% below 2010 levels by 2030 and to reach net-zero emissions around 2050 for CO_2 emissions and net-zero total GHG emissions around 2070.

In recent years, measures to reduce GHG emissions have, in many cases, become more attractive to policy makers and private investors in many countries, both because of falling technology costs, as well as increased awareness for other benefits, such as air quality improvements and job creation in low-carbon-oriented sectors, in addition to the avoided climate change damages and related costs. These socio-economic benefits of climate change mitigation unfortunately are not yet in the centre of the climate policy debate in Australia.

We no longer live in a world where climate change mitigation is a burden *per se*, but one where it is increasingly the most feasible, cheapest option when considering all socio-economic aspects. For cost-efficient global mitigation, it will be essential to overcome remaining barriers in all countries including Australia.

This report, the sixth country assessment in the Climate Action Tracker's Scaling Up Climate Action Series, shows where Australia can accelerate its climate action. The report illustrates GHG emission reductions from these actions, along with employment and other benefits and the policies across all sectors that will bring emissions down fast enough.

Our analysis starts with an in-depth review of Australia's current policy framework and sectoral developments and compares them with the comprehensive policy packages and the progress of the kind of sector indicators required under Paris Agreement-compatible pathways.

It then focuses on a scenario analysis showing how to scale up climate action in Australia to levels consistent with the Paris Agreement. This analysis shows the huge gap between Australia's present sectoral emission trajectories under the Current Development (reference) scenario and the sectoral transformations that the country can undertake to align with the Paris Agreement's temperature limit.

Additionally, we investigate the sectoral transformations that can be undertaken in Australian by following the benchmarks set by the international frontrunners ('best-in-class'). In particular take the specific characteristics of Australia's industry sector and the importance of extraction and export of fossil fuels, as well as the key role of the power sector to decarbonise end-use sectors through (direct and indirect) electrification, and show what can be done to decarbonise these sectors by 2050, or earlier.

We focus on the potential to increase mitigation efforts in the electricity supply, transport, industry, and buildings sectors, while providing an integrated energy system approach and a pathway for greenhouse gas emissions reductions across all sectors consistent with the Paris Agreement.

The report identifies Australia's options for accelerated climate action in each sector, informed by insights from three different scenario categories: (1) National scenarios, (2) Scenarios applying sectoral best-in-class levels, and (3) 1.5°C Paris Agreement-compatible scenarios, the results of which have all been compared to the common baseline of (4) the Current Development Scenario.

	Scenario categories	Definitions
1	**NATIONAL** SCENARIOS	Scenarios based on national research and country-specific studies (analysed for some sectors)
2	**BEST IN CLASS** SCENARIOS	Scenarios based on best practices implemented by regional or international frontrunners (analysed for some sectors)
3	**1.5°C PARIS AGREEMENT COMPATIBLE** SCENARIOS	Scenarios based on sectoral developments in line with the Paris Agreement's temperature limit.
4	**CURRENT DEVELOPMENT** SCENARIO	Reference scenario used for comparison purposes. The scenario is based on the continuation of current trends and policies until 2050.

KEY FINDINGS

- Australia's 2030 Paris Agreement target and its domestic policies are not compatible with the Paris Agreement's 1.5°C limit. Australia will need to accelerate its climate action across all sectors of the economy and ratchet up the 2030 climate target to put the country on a path towards net zero GHG emissions by 2050.
- Increased climate action in Australia will achieve a wide range of benefits and can build on existing technologies and current market developments to achieve cost reductions, particularly for wind, solar and storage technologies by taking advantage of the country's extraordinary renewable energy resources.

2030 targets need major improvement

- Accelerated climate action in line with the Paris Agreement-compatible scenarios across all sectors allows Australia to achieve emission reductions of about 50% below 2005 emission levels by 2030, and 90% reductions by 2050, excluding the uncertain and volatile Land use, land-use change and forestry (LULUCF) sector.
- To achieve net zero by 2050 Australia's 2030 GHG reduction target (including LULUCF) needs to be about 66% below 2005 levels. This is very close to the high end of the 2030 target range recommended by the Climate Change Authority in 2014 of 47-65% below 2005 emission levels.

Achieving net zero by 2050

- Australia can achieve net zero GHG emissions by 2050 if it takes action to halt deforestation by 2030, and if it maintains the storage of carbon in forests projected for 2030 until 2050. This would be needed to outweigh remaining greenhouse gas emissions from hard-to-abate sectors, particularly agriculture.
- Achieving net zero GHG emissions by 2050 will require a whole of economy approach, with mitigation in the non-energy sectors alongside decarbonising electricity and electrification of industry and transport, the roll-out of renewable hydrogen and a balanced approach in the land-sector that protects biodiversity, water resources and avoids relying on carbon storage in the land sector beyond sustainable limits.

Major Employment generation by decarbonising the power sector

- The key to decarbonising Australia's energy system is decarbonising the electricity sector.
- Accelerating the transition towards a zero carbon, renewables-based electricity supply by the 2030's will bring large domestic employment opportunities to Australia
  - 46,000 additional jobs between 2021-2030 compared to the current trajectory
  - If combined with a policy to incentivise more local manufacturing of wind turbines, solar panels and batteries would reach 76,000.
- Australia can decarbonise its domestic energy system by 2050 by scaling up action in the electricity supply, and energy end use sectors (manufacturing industry, transport and building sectors) —which cover around 70% of the Australia's current greenhouse gas emissions.
- Electrification of end-use sectors is central to decarbonising the Australian economy, including electric mobility and green hydrogen for industry and transport, with benefits for the electricity system.
- Australia needs to urgently prepare for the global transition away from fossil fuels as the world implements the Paris Agreement with many countries now aiming for zero emissions by 2050 and can develop alternatives to exporting fossil fuel energy.
- By building on its extraordinary renewable energy resource and high skills base, Australia can become a regional and international frontrunner in successfully transitioning its energy system to zero carbon. The result will be more sustainable employment, reduced levels of air pollution, water demand and new manufacturing value chains and export opportunities based on zero emissions energy carriers including renewable electricity offshore, green hydrogen and energy intensive products such as green steel.

Electricity generation

- The electricity supply sector in Australia can be fully decarbonised, reaching 100% renewable energy by the mid to late 2030s given Australia's prime renewable energy resources and technology developments for wind, solar, and storage already underway
- Coal can be phased out of the power sector by 2030 using renewables and advanced storage without additional gas generation needs, consistent with what is needed globally to meet the Paris Agreement's goals.
- Coal phase-out plans are needed that will enable a smooth and just transition.
- Gas can be phased out of power sector by the mid to late 2030s using renewables and advanced storage. This study confirms that there is no role for an increase in gas use for power generation in a Paris Agreement-compatible pathway.

Renewable Energy and Green Hydrogen is a major opportunity for Australia

- Green hydrogen and other renewable energy-based fuels can be used to decarbonise industry processes to produce zero emissions steel or ammonia, and be used for aviation, shipping and freight transport through fuel cell trucks.
- Australia can benefit from its unique and abundant resources, both in renewable energy and the range of minerals and materials needed for a global transition to 100% renewable energy, but needs clear strategy and plan. It has the opportunity to become a global leader through, for example, exporting zero emissions energy carriers and products such as green steel.

Electric Mobility

- The phasing in of electric vehicles (EVs) can happen rapidly so that there would be no new fossil-fuel based vehicles sold from 2035 onwards.
- EVs will reduce air pollution and overcome fuel security concerns, with significant benefits to the economy.
- The need for imported fuel oil presently imposes an import cost burden of 1.5% of GDP (in 2018) with import dependency expected to increase under present policy settings.
- By accelerating EV market development fuel oil usage would be reduced by 24% by 2030 from 2005 levels and 100% by 2050, resulting in an entirely decarbonised transport sector.
- Integration of EVs into the Australian power grid will also provide substantial benefits for the electricity system, lowering costs and contributing towards integrating higher shares of variable renewables like wind and solar.

Reducing emissions from the LNG sector

- Natural gas will need to phased out globally for power generation by the 2040s to meet the Paris Agreement goals, however the domestic LNG industry will need to substantially reduce its own emissions well before that time.
- Emissions from the LNG industry can be substantially reduced by capturing and storing carbon dioxide that would otherwise be emitted in very large volumes from natural gas reservoirs, using renewable energy for the process of liquifying natural gas and upstream pumping and transport of gas rather than use the gas itself, and, as well, reducing fugitive emissions from LNG plant and related processes.
- Renewable electrification of LNG processing plant can play a key role in phasing out emissions from LNG processing industry in Australia. Transitioning the LNG manufacturing process away from gas to renewable electricity will also add significantly to the renewable energy market in Australia with opportunities for regional Australia.

Sectoral transitions towards zero-carbon

This report shows that Australia, has tremendous potential to scale up climate action in all sectors. Here we focus on the key sectors: electricity supply, industry (including LNG production), transport, and buildings.

Increasing climate action would initiate sectoral transitions towards a zero-emissions society relying on existing and, in some sectors, emerging technologies. This would come with the additional benefits of reducing air pollution, and creating additional employment including through new manufacturing value chains and new export opportunities based on renewable energy.

Electricity supply

Australia has no targets nor plans to increase the share of renewable energy beyond 2020. Under existing policies, Australia would likely reach a share of renewable energy in electricity generation nationally of around 50% by 2030 depending on state targets to be achieved.

The policy void at federal level is creating investment uncertainty and there is an urgent need to plan for a fast transition to 100% renewable energy in the 2030s with corresponding transmission and storage planning and investments. Current developments and the lack of targets and planning are leading to reduced investments, where acceleration is necessary.

For Paris Agreement compatibility the uptake of renewable energy in electricity supply needs to, and can, be accelerated, to reach a share of almost 97% in 2030, 99% by 2035 and 100% by 2040, with an increase in electricity generation by 32% in 2030 above 2019 levels and further 23% in 2040 above 2030 levels to enable electrification of end use sectors, including EVs in transport and green hydrogen for domestic use. An additional increase would be needed to allow for new export opportunities, such as green hydrogen or direct export of electricity to South East Asia, but has not been analysed in this study.

This accelerated uptake of renewable energy is more ambitious than the step-change scenario in the 2020 Integrated System Plan (ISP) for the National Electricity Market by Australian Energy Market Operator (AEMO) which reaches 94% renewables share in electricity generation in 2040. The AEMO scenarios do not account for the scale of increase in electricity generation needed to decarbonise all end use sectors by 2050, nor any additional increase to enable new export opportunities such as green hydrogen.

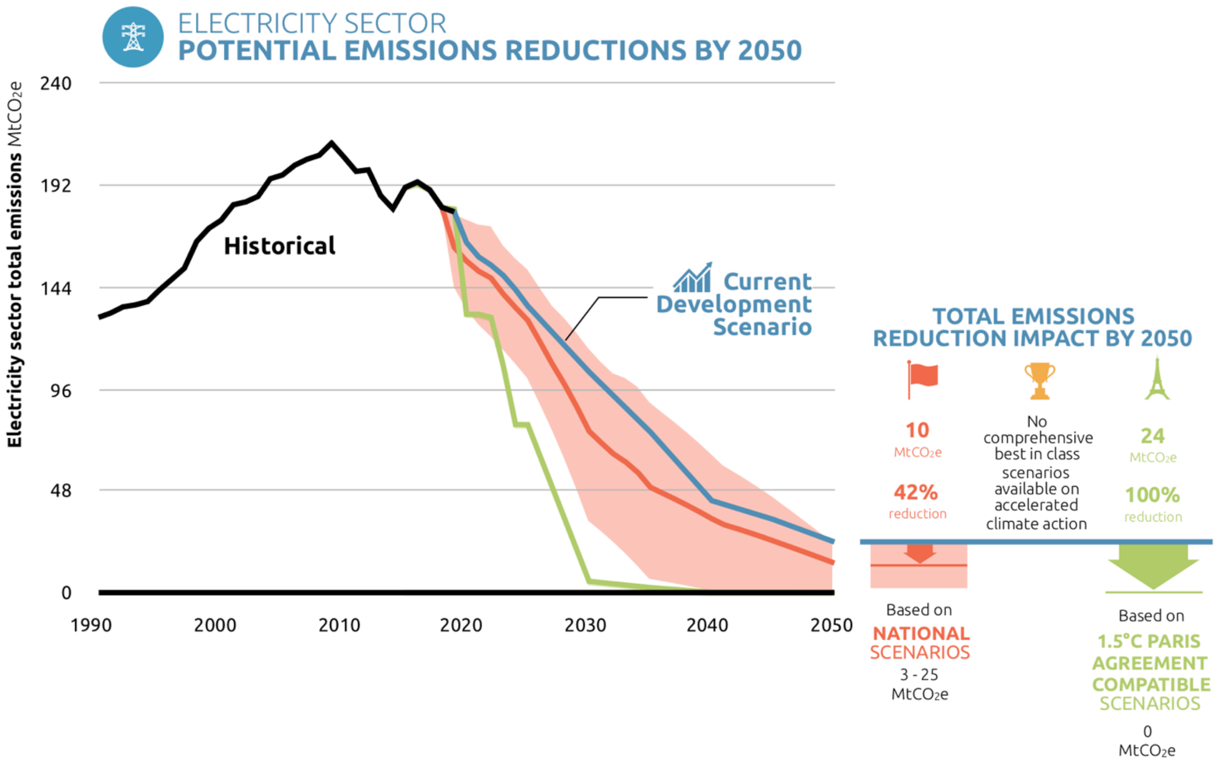
Table 1: Identification of indicator levels for scaling up climate action in the Australia's electricity supply sector. Shown is the share of Renewable energy in total power generation resulting from the scenarios under the assumptions for the two scenarios categories.

	Reference Scenario (REF)	National scenarios	1.5°C Paris Agreement Compatible scenario
Share of renewables in total electricity generation	**13% by 2015**	-	-
	53% by 2030	**59-84% by 2030**	**95-97% by 2030**
	79% by 2040	**82-99% by 2040**	**99% by 2035 and 100% by 2040**
	89% by 2050	**92-100% by 2050**	**100% by 2050**
References	*Based on AUSeMOSYS developed by Climate Analytics* (Tino Aboumahboub, Brecha, Shrestha, et al., 2020)	*Based on 'Advanced Renewables' Scenario by* (Teske et al. 2016) *for the High ambition case and 'Fast Change Scenario' by* (AEMO, 2018a) *for the Low ambition case. Other published national scenarios fall within this range.*	*Based on AUSeMOSYS developed by Climate Analytics* (Tino Aboumahboub, Brecha, Shrestha, et al., 2020)

Planning for renewable energy expansion needs to include grid transmission systems and electricity market adjustments.

An essential step to decarbonising electricity generation is a planned phase-out of coal-fired power generation by 2030. This needs to be a planned and regulated process to enable a just transition particularly for regions currently highly dependent on coal-fired power generation and coal mining.

This transition does not require an increase in gas for power generation due to the increasing cost efficacy of battery storage, pumped hydro systems, demand-side management measures and later the integration of hydrogen and EV storage systems into the grid.



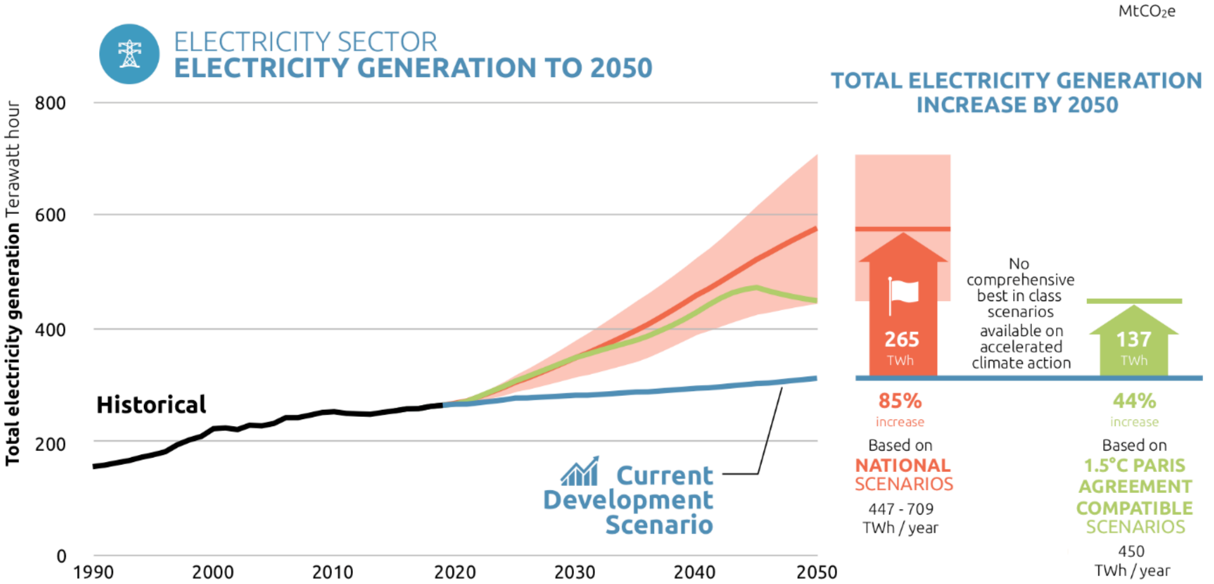


Figure 1: Overview of sectoral emission pathways under reference scenario projections and different levels of accelerated climate action in the Australia's electricity supply (top). The projected electricity demand considers accelerated climate action in the Australia's end-use sectors which leads to higher electricity generation (bottom). Based on AUSEMOSYS energy model developed by Climate Analytics (Tino Aboumahboub, Brecha, Shrestha, et al., 2020).

Note: In the Australia's electricity supply figure (top) the CO_2 emissions begin reducing from 2019 reflecting the model output. With action starting a year or two later a similar level of emissions reductions would still be achieved by the mid-2020s as coal plant are phased out. This adds about 0.1GtCO_2 to the cumulative emissions from 2018-2050.

In our modelling using the optimization approach in Australian Energy Modelling System (AUSeMOSYS), the share of gas for power generation decreases from today's level of about 20% to around 3% by 2030, 1% by 2035 and is completely phased out by 2040. This is contrary to statements by the government that more gas will be needed as a transition fuel or as a partner for renewable energy, and contrary to government plans to subsidise new gas-fired power plants.

Renewable energy-based power generation leads to reduced electricity prices and reduced health impacts avoiding air pollution from coal and gas fired power generation.

Transport

The upward trends of GHG emissions from the transport sector in Australia highlights the urgent need to accelerate action to fully decarbonise this sector by mid-century to be compatible with the Paris Agreement.

The CAT Paris Agreement-aligned benchmark requires Australia to increase its share of electric vehicles (or other emissions-free vehicles) in new vehicle sales from less than 1% today for personal cars, light duty vehicles and buses to 95% in 2030 to reach 100% in 2035.

This would translate into about a 38% EV share in the total fleet of cars and buses on the road in 2030 and, combined with the decarbonisation of the power sector, would result in full decarbonisation of this fleet by the middle of the century. In order to achieve this, Australia would need to apply stringent standards for CO_2 emissions intensity of new vehicles and increase the share of public transport.

A similar approach will be needed for trucks so that zero-emissions trucks would constitute 100% of newly sold trucks by around 2035-2040, leading to an almost 100% zero-emissions truck fleet by 2050. Options for zero-emission trucks at present include battery and fuel cells powered by Green Hydrogen.

For domestic aviation, technologies are also emerging in zero emissions fuels, such as synthetic jet fuel made from renewable energy using power to liquid technologies (P2L). We assume full decarbonisation of domestic aviation by 2050, which might imply the need for negative CO_2 emissions to compensate for remaining fossil fuel use.

Full decarbonisation of Australia's passenger and freight transport sector by 2050 is possible and requires a substantial modal shift for passenger and freight transport, introducing zero-emission vehicles, CO_2 fuel economy standards for cars, light duty vehicles, buses and freight vehicles. Internal combustion engine vehicle sales would need to be banned from 2035 at the latest.

Transport decarbonisation would build on the decarbonisation of the electricity supply sector, which would be decarbonised by the mid to late 2030s. This pathway reduces air and noise pollution and their harmful effects on health, and significantly reduces and eventually remove reliance on oil imports.

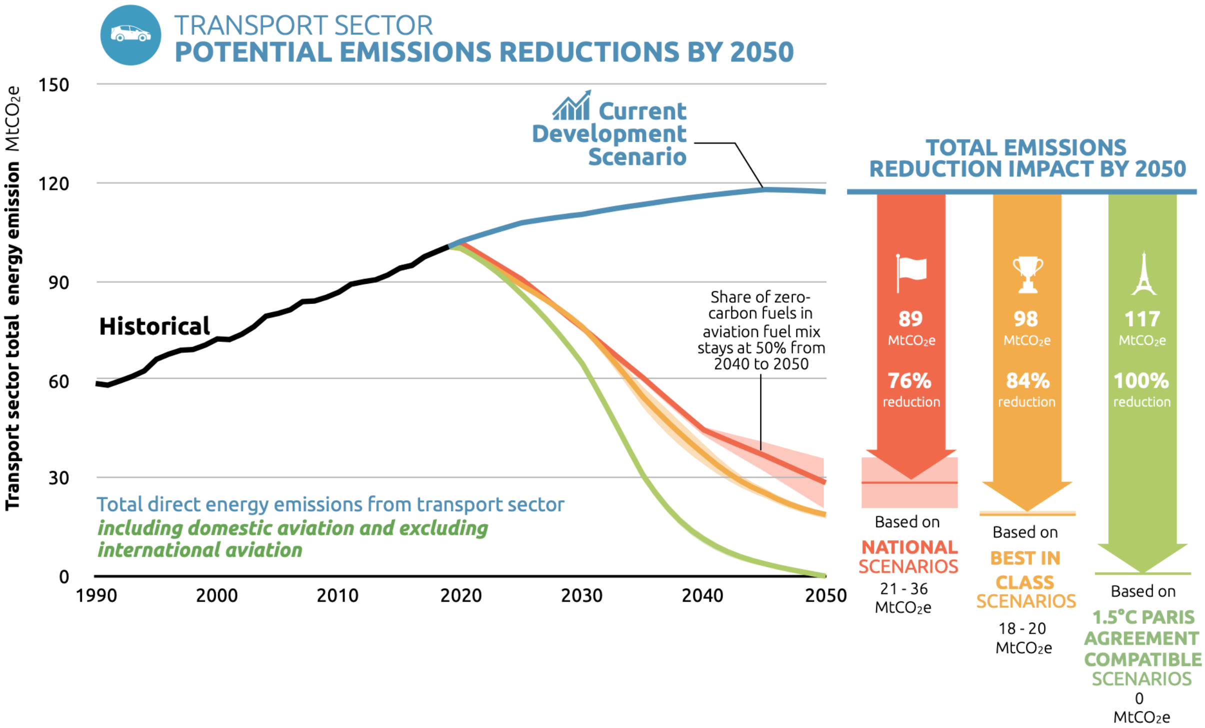


Figure 2: Overview of sectoral emission pathways under current policies and different levels of accelerated climate action in passenger and freight transport including domestic aviation. The CAT PROSPECTS Australia scenario evaluation tool has been used to estimate sectoral projections towards 2050. Historical emission levels have been harmonised to national inventory data. Shown are total direct emissions from the transport sector excluding electricity related emissions.

Buildings

Australia lacks a strategy to reach a 1.5 °C consistent benchmark in the residential and commercial buildings sector. There is widespread undercompliance with the present minimal energy efficiency standards, which are not due to be updated until 2022. Slow policy responses for long-lived assets mean that renovation rates will need to be scaled up, but there is no policy at all that focuses on increasing building renovation rates. Australian efficiency standards are behind other countries with similar climates. Failure to ensure adequate levels of energy efficiency in buildings places further pressure on the electricity grid to decarbonise.

The Paris Agreement-compatible trajectories almost fully decarbonise the buildings sector by 2050. Energy savings would need to be achieved through a deep retrofit of existing buildings at a 5% renovation rate per year from 2020 to 2050. In parallel to construction of zero-emissions new buildings, energy efficiency improvement of lighting and appliances as well as strong electrification (e.g. heat pumps) or other technological shifts to renewable energy in space/water heating can fully decarbonise the Australian buildings sector by mid-century. Decarbonising this sector critically relies on decarbonising the electricity supply sector.

There are direct benefits to households and businesses in decarbonising this sector, from thermal comfort to the financial savings by reducing electricity usage and installation of onsite renewables. Effective management of energy in buildings can reduce grid peak demand, reducing capital costs for further generation. Energy efficiency in buildings has been linked to improved health and productivity, improved air quality, economic growth and job creation.

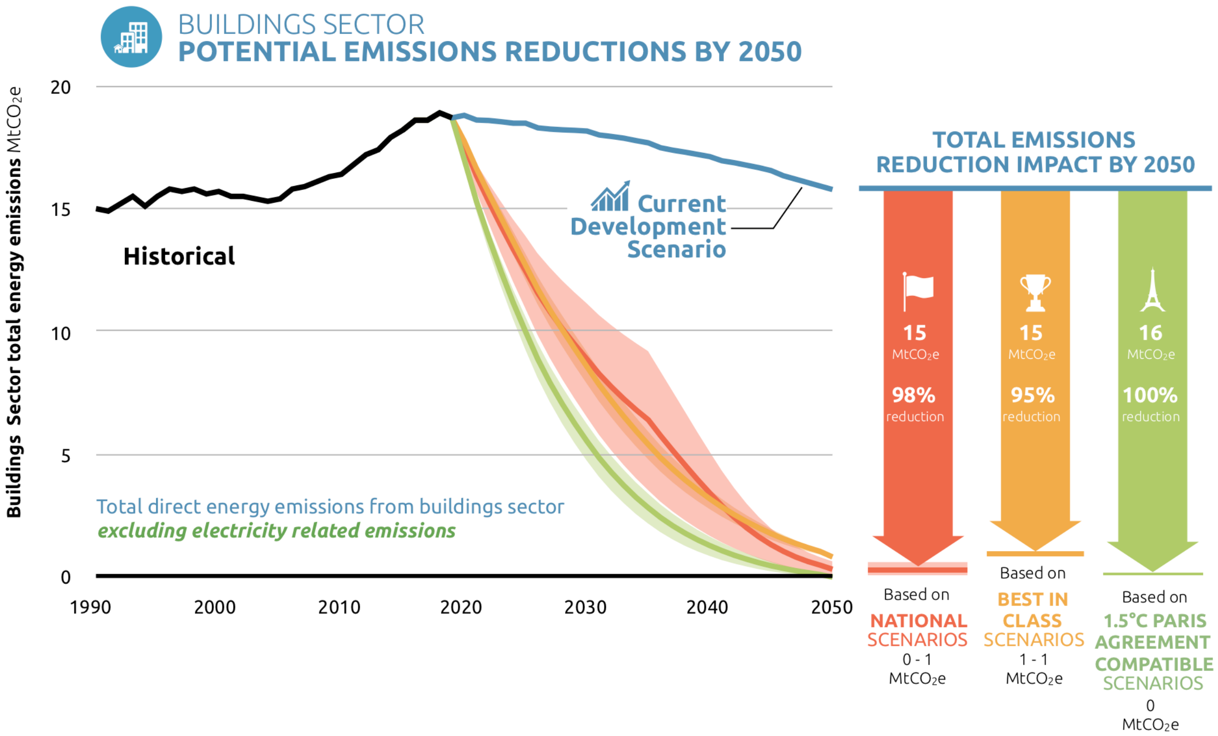


Figure 3: Overview of sectoral emission pathways under current policies and different levels of accelerated climate action in the buildings sector (domestic and commercial). The CAT PROSPECTS Australia scenario evaluation tool has been used to estimate sectoral projections towards 2050. Historical emission levels are harmonised to latest inventory data. Shown are total direct emissions from the residential and commercial building sector excluding electricity related emissions.

Industry

Australia's emissions from industry (direct combustion, fugitives, and industrial processes) account for 30% of total emissions (excl. LULUCF), making it the second largest emitting sector.

However, there is no strategy in Australia to achieve decarbonisation in the industry sector. Implementing energy efficiency policies across all industry sectors are key steps in reducing emissions and saving money.

Many heating processes in industry can be replaced to use electricity which can be produced 100% from renewable energy sources, mainly wind and solar. In other processes such as high-temperature heating or ammonia production, fossil fuel gas can be replaced by hydrogen or other fuels based on 100% renewable energy power. Australia's abundance of solar and wind energy can prompt international trade in renewables through hydrogen-rich chemicals and fuels or new zero emissions production.

Decarbonising Australia's industry sector needs to go beyond incremental improvements through increased energy efficiency. This needs to build on fuel switching and innovation leading to material efficiency, and process and product changes. This needs policy intervention through regulation, removal of barriers and concerted RD&D efforts by government and industry.

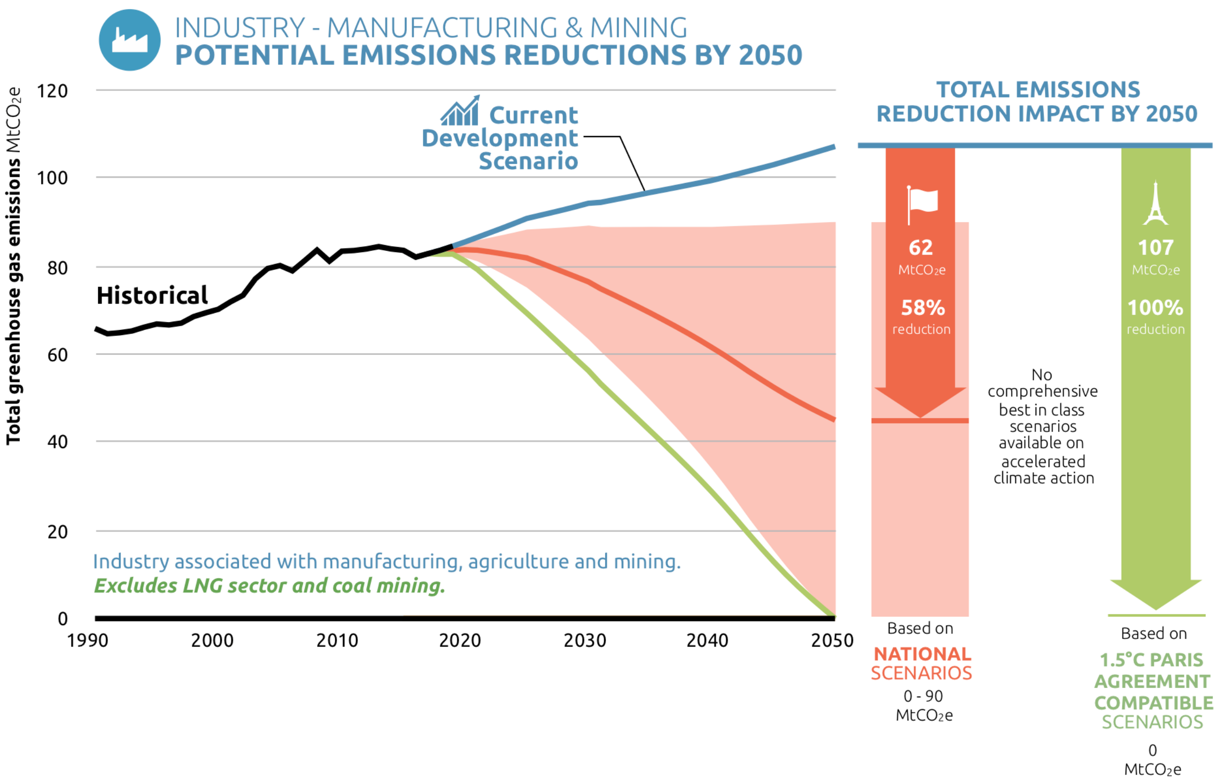


Figure 4: Overview of sectoral emission pathways under current policies and different levels of accelerated climate action in the industry manufacturing and mining sector (including steel and cement). The CAT PROSPECTS Australia scenario evaluation tool has been used to estimate sectoral projections towards 2050. Historical emission levels are harmonised to the latest inventory data. Shown are total direct combustion emissions and process emissions as well as emission from product use from the industry manufacturing sector excluding electricity related emissions. This includes the mining sector, but does not include the energy/fossil fuel extraction sector.

The industry sector is varied, and challenges differ significantly, but technologies with significant decarbonization potential are available as well as emerging across the industry sector. Electrification and green, renewable, hydrogen technologies with zero-emissions power are the key. A concerted effort guided by policy and targets is needed, to achieve transformational change including in sectors such as steel and cement where technologies to decarbonise these processes exist or are emerging.

Long lead times of investments in industry infrastructure mean these efforts need to start as soon as possible to enable the transition to zero emissions by 2050. A well-managed and planned transition can lead to large benefits for employment and growth through innovation and new manufacturing value chains and export opportunities based on zero emissions energy carriers including green hydrogen, energy intensive products such as green steel and aluminium.

Industry – the Liquefied Natural Gas sector

Australia contributed to around one-fifth of total global LNG capacity in 2018, most of this from Western Australia. In 2019, Australia overtook Qatar to become the largest exporter of LNG in the world. The future trend of LNG export volumes will have a major effect on Australia's domestic emissions.

Australia's LNG export volumes are forecast to increase from 62 million tonnes in 2017–18 to 82 million tonnes in 2019–20; the export volumes are forecasted to 81 million tonnes by 2023 (DIIS 2019). Here, we project the LNG export volumes under the "Reference Scenario" to reach to 87 million tonnes by 2025 and further rise to 97 million tonnes by 2030, and that volumes remain constant beyond 2030.

LNG manufacture is very energy-intensive, with about 10% of the feedstock gas being used to manufacture LNG. As a consequence, CO_2 emissions from gas used for energy in LNG plant during the period 2017-2019 comprised about 41 to 44% of the total emissions from the sector. Fugitive emissions from production and liquefaction can also be significant and have been estimated here at 11 to 12% of the total during the same period.

Natural gas reservoirs contain large amounts of carbon dioxide, which we estimate account for 16 to 21% of emissions in this period.

There is also significant energy use in upstream production of natural gas, estimated here in the range of 16 to 18% of total emissions in the sector. Coal Seam Gas (GSC) production in Queensland also consumes a significant amount of electricity which, based on the states' present energy mix, amounts to 9% to 12% of total LNG emissions nationally.

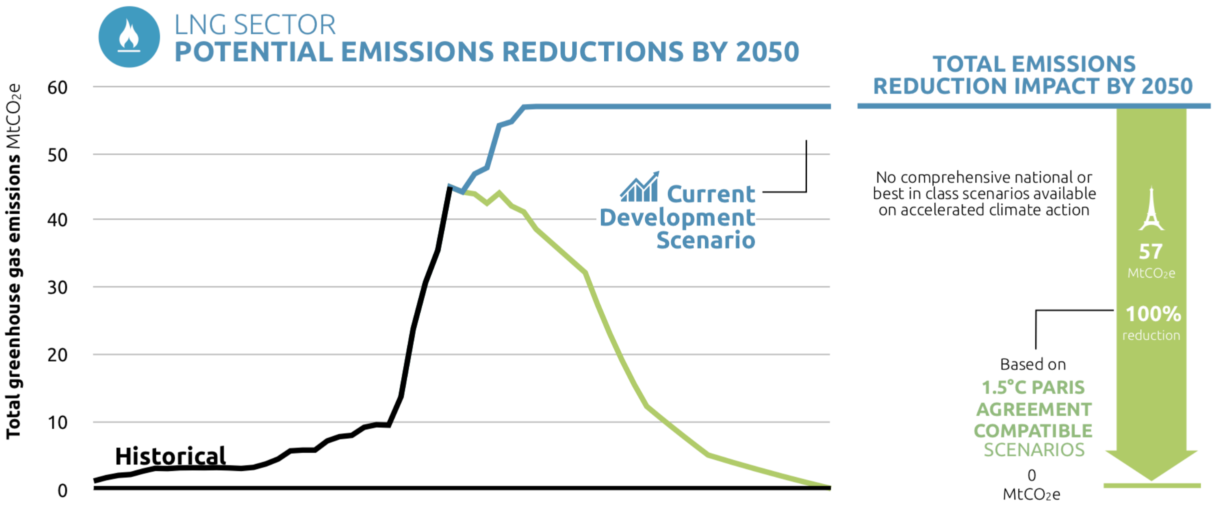


Figure 5: Overview of sectoral emission pathways under current policies and different levels of accelerated climate action in the LNG sector. Shown are total LNG related emissions – CO2 venting, direct combustion emissions from upstream production and LNG manufacturing, fugitive emissions.

An essential option for abatement in the LNG sector is to ensure that reservoir CO_2 is captured and stored, rather than released into the atmosphere. In Western Australia this is a very significant component of the overall emissions from LNG production. The LNG production process must capture the CO_2 in the natural gas reservoir from the gas stream, and it should be well within the means of industry to achieve its storage and transport to an appropriate geological storage reservoir. In this study we assume that the 80% CCS capture rate planned for the Gorgon plant from 2019 is phased in to all LNG plants from around 2023.

Processes in the LNG plant themselves require electricity and energy for refrigeration. The corresponding CO_2 emissions can be avoided by using renewable electricity in the LNG manufacturing process, which in large part is essentially driven by aeroderivative gas turbines. This would also assist in reducing fugitive emissions from the LNG plant.

Renewable electrification of LNG processing plant can play a key role in phasing out emissions from LNG processing industry in Australia. Where electricity is used in upstream gas production, this can also be transitioned to renewable sources.

In the '1.5°C Paris Agreement-compatible' scenario in this study, Asian gas demand declines continuously from 2030 onwards. We assume that LNG export volumes would follow this decline towards an 80%-96% reduction of export volumes by 2050 below 2030 export levels. The basic options mentioned above - carbon capture and storage of reservoir CO_2, introducing renewable energy quickly into the upstream gas production and LNG manufacturing process and reducing fugitive emissions are all deployed in the Paris Agreement-compatible scenario shown in the figure below. If the assumed decline in LNG export volumes does not occur – and LNG exports follow the reference case (with constant export volume assumed after 2025), all of the above options would be needed, but at a larger scale.

Industry – other energy/extraction industry

The 1.5°C Paris Agreement-compatible pathway substantially reduces emissions and leads to the full decarbonisation of the mining industry by 2050. This is mainly driven by the strong electrification of the mining sector and use of decarbonised electricity from grid as a replacement to fossil fuel-based onsite generation.

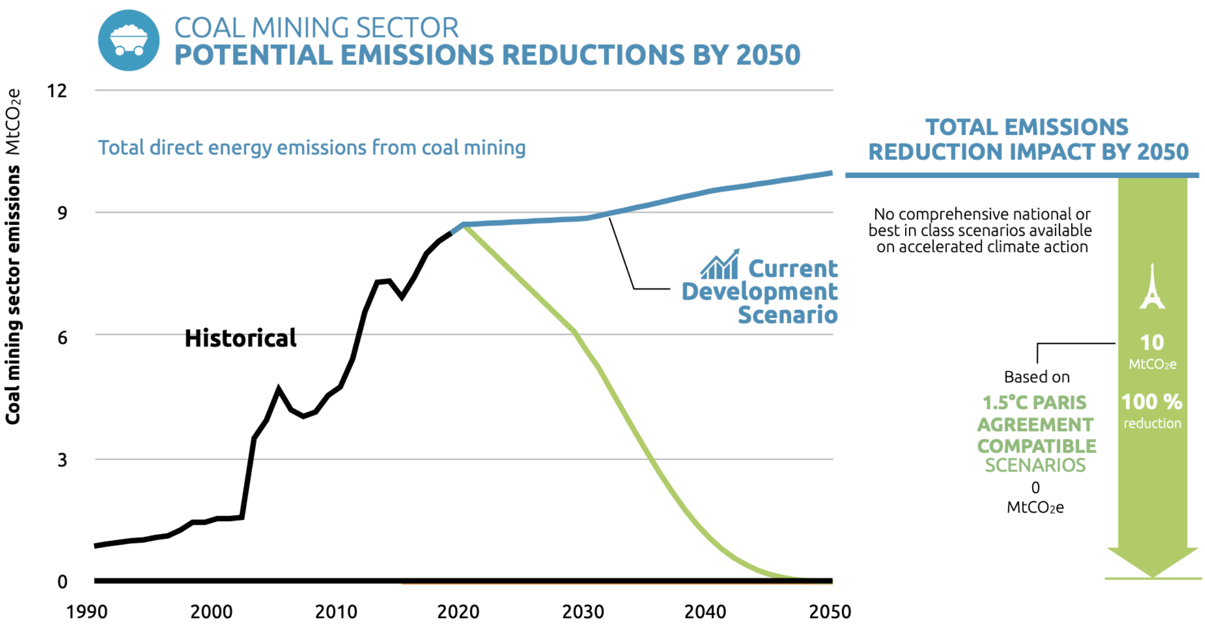


Figure 6: Overview of sectoral emission pathways under Reference scenario projections and accelerated climate action in Australia's coal mining sector.

One major mitigation strategy for mining companies is the use of decarbonised renewable electricity from the grid instead of onsite fossil-fuel based generation. This is already being deployed in some cases. Further complementary strategies to increase energy efficiency as well as electrification of energy end uses that have been so far powered by fossil fuels would yield further reductions.

In the **1.5°C Paris Agreement-compatible pathway,** coal mining declines from 2020 onwards towards a complete phase out of coal production by 2050, due to the replacement of thermal coal in the domestic power sector by 2030 and globally by 2040, and as metallurgical coal is gradually replaced by zero carbon alternatives, such as green hydrogen in steel manufacture.

Agriculture

At present in Australia there are few specific policies to reduce emissions from the agriculture and forestry sectors.

In general, reductions of non-energy emissions in the agricultural sector, particularly of methane and nitrous oxide, are expected to be much slower than in all other sectors. Key mitigation options include enhanced agricultural management (e.g. manure management, improved livestock feeding practices, and more efficient fertiliser use), as well as demand side measures such as dietary shifts to healthier, more sustainable, low-meat, low-dairy diets and measures to reduce food waste.

The 1.5°C Paris Agreement-compatible pathways for the agriculture sector project a 35% reduction of methane and nitrous oxide emissions relative to 2005 levels by 2050.

Waste

State and national policies do not provide a pathway to emissions reductions in this sector, as they do not focus on emissions. **Australia needs to scale up its national waste policy with more ambitious targets to tackle emissions, focusing on organic material waste.** Under the 1.5°C Paris Agreement-compatible pathway, emissions from the waste sector show an immediate and drastic reduction, declining to approximately 73% in 2030 below 2005 levels and about 3 $MtCO_2e/a$ in 2050.

Mitigation in the waste sector in particular is focused on reducing landfill emissions as this is highly cost effective and could even return a net profit. Key options in the short term to reduce emissions are lower landfill levels and an increase in methane capture. In the longer term, there is a need to move towards a circular economy, prioritising collection, recovery and re-use of products.

Accelerated climate action and Australia's inadequate 2030 emissions reduction target

Accelerated climate action in line with the Paris Agreement-compatible scenarios across all sectors would allow Australia to achieve emission reductions of about 50% below 2005 emission levels by 2030 (excluding LULUCF).

Assuming the 2019 Federal Government's projections for land use change and forestry (LULUCF) of a net sink in 2030 of 10 $MtCO_2e$, the reductions in the Paris agreement-compatible pathway here translates into a reduction including LULUCF of about **59% by 2030 below 2005 emission levels. A strategy to halt deforestation by 2030 would increase this to a 66% reduction in all greenhouse gases, including the land sector, by 2030 below 2005 levels. This would be the appropriate Paris Agreement-compatible target for Australia to update its NDC in 2020, as agreed in Paris in 2015 and the appropriate milestone towards net zero emissions by 2050.**

An important conclusion from these findings is that it is beneficial for Australia to considerably ratchet up its 2030 target to be consistent with the Paris Agreement. Increased climate action will achieve a wide range of benefits, it can build on existing technologies and current market developments and achieve cost reductions, particularly for wind, solar and storage technologies as well as take advantage of the country's extraordinary renewable energy resources.

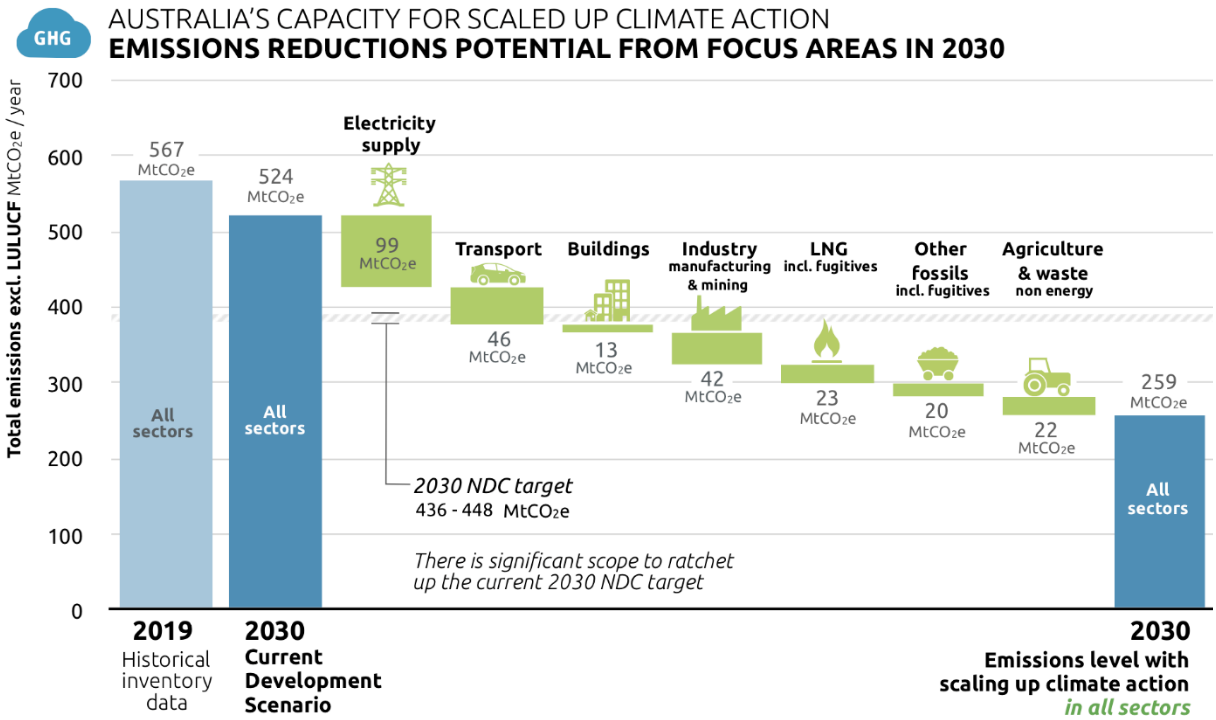


Figure 7: Overview of total emission levels (excl. LULUCF) under historical inventory data in 2019 (left bar), under a Reference Scenario in 2030 (middle bar), and most ambitious levels of accelerated climate action by 2030 in all sectors.

A strategy towards net zero emissions in 2050

When determining its long-term strategy by mid-century, Australia needs to act quickly on a fast decarbonisation of the power sector and recognise this sectors role in decarbonising end use sectors, including industry and transport. It will need to define sectoral targets and roadmaps, and implement more ambitious and stringent policies across all sectors to initiate and steer these sectoral transformations, given long lead times for infrastructure in industry, transport, and buildings.

Emissions from agriculture and waste cannot be reduced to zero, and some of the processes - especially in heavy industry, aviation and shipping - will likely need a bit longer to decarbonise than other sectors (Figure 8). Figure 9 provides and overview and summary of the sectoral results from this study.

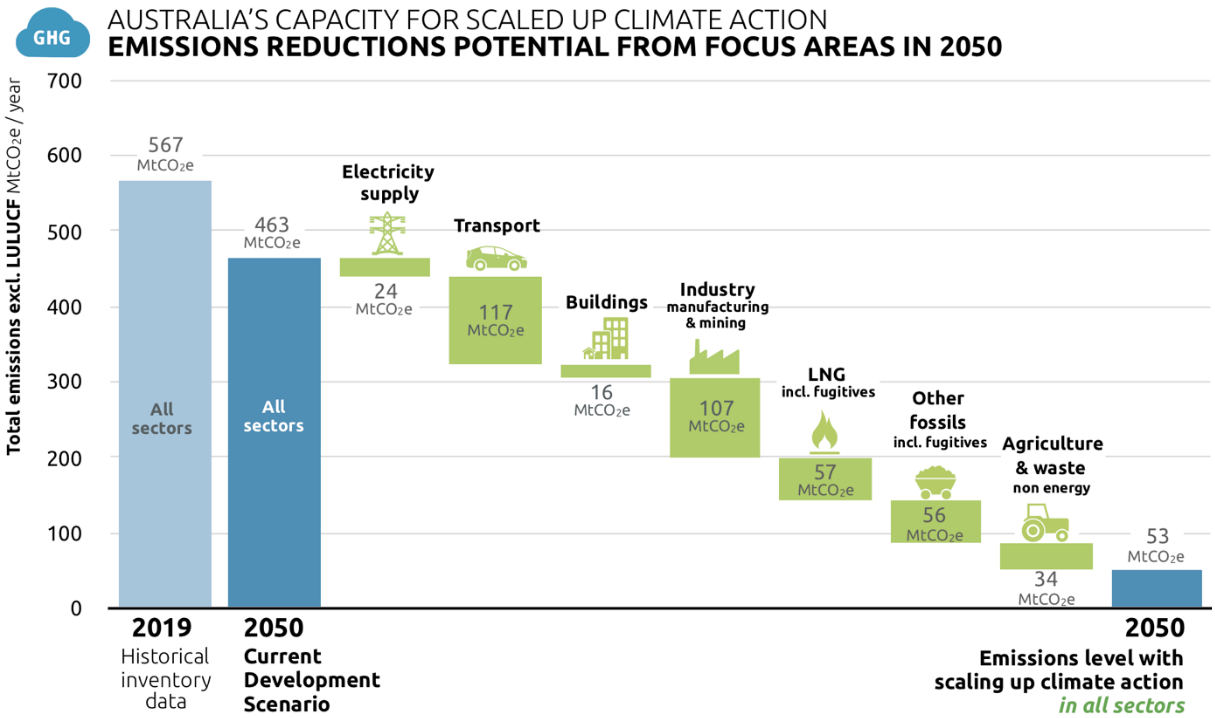


Figure 8: Overview of total emission levels (excl. LULUCF) under historical inventory data in 2019 (left bar), under a Reference Scenario in 2050 (middle bar), and most ambitious levels of accelerated climate action by 2050 in sectors (right bar).

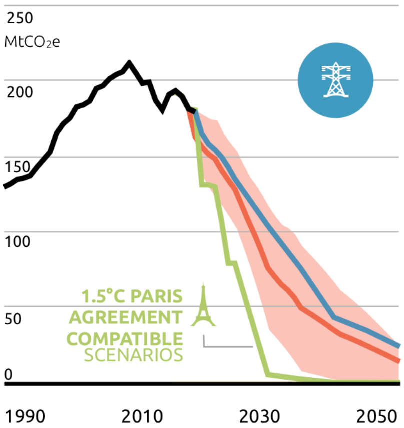
In overall greenhouse gas terms The 1.5oC scenario for Australia developed here, with all options considered, gets to a 90% reduction in emissions (excluding LULUCF) by 2050, with about 50 $MtCO_2e$ per year remaining (Figure 10).

Net zero GHG emissions by 2050 cannot be achieved even with this ambitious strategy unless there is a significant increase in the amount of CO_2 stored in the land sector. With the government's 2019 land-use change and forestry projections to 2030 extrapolated until 2050 GHG emissions of 93% from 2005 levels may be achievable by 2050. Net-zero greenhouse gas emissions would not occur until the 2070s, at the earliest assuming that there are slow reductions in the non-CO_2 emissions from hard to abate sectors.

Achievement of net-zero GHG emissions needs a significant increase in the storage of carbon in Australia in the land sector.

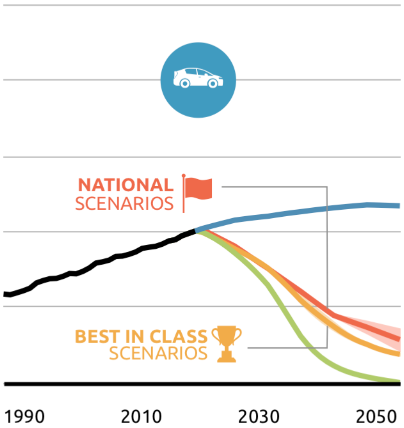
SCALING UP CLIMATE ACTION IN AUSTRALIA
POTENTIAL EMISSIONS REDUCTIONS IN FOCUS AREAS BY 2050

ELECTRICITY SUPPLY



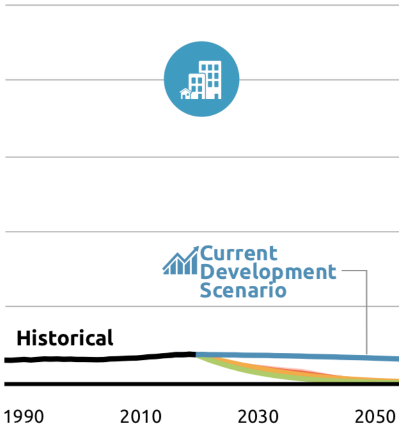
- Policy continuity and targets to support accelerated uptake of renewable energy.
- Phase out coal from power generation by 2030, with a strategy to ensure a just transition from coal mining and electricity generation.
- Grid infrastructure investment and energy market reforms to support uptake of demand management and storage at all scales (household to industrial).

TRANSPORT



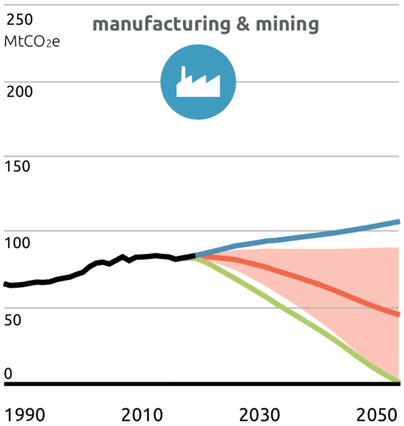
- Set ambitious greenhouse gas emission standards (at least as ambitious as the EU) both for passenger and heavy transport.
- Announce ban on sales of internal combustion cars and LDVs by 2035.
- Programmes to transition the truck fleet to renewable energy sources.
- Concerted initiatives with industry to decarbonise aviation and maritime shipping and develop market for carbon free fuels including bio jet fuel, and P2L technologies.

BUILDINGS



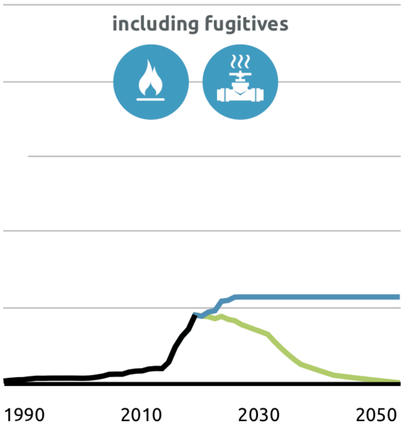
- Commit to national zero carbon ready building code and ensure compliance.
- Progressive requirements and incentives for buildings to include renewables and storage with EV re-charging capabilities.
- Increase awareness and information about energy efficiency benefits, ensure transparency through disclosure schemes, and introduce incentives.
- Energy rating requirements on property transfer and sale.
- Ban fossil fuels for heating from 2030 onwards.

INDUSTRY



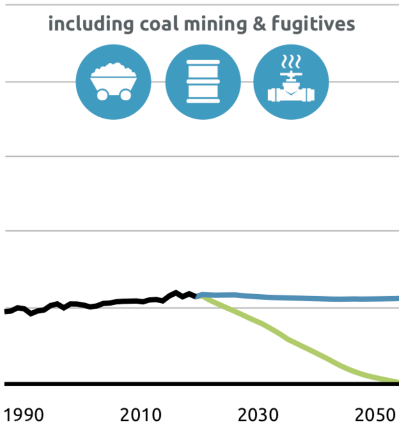
- Replace the ineffective safeguard mechanism with an effective carbon pricing system
- Implement best practice policies such as incentives for Energy management, mandatory energy audits.
- Programmes and incentives for zero carbon mining and metal production
- Establish a defined Paris-compatible decarbonisation pathway and strategy, and targeted sectoral R&D
- Hydrogen strategy needs to focus on renewable hydrogen

LNG



- Carbon pricing or regulation to ensure electrification and phasing in of renewable energy.
- Mandatory capture and storage of reservoir CO_2.
- Mandatory reduction targets and independent MRV for fugitive emissions
- Approval process for LNG projects takes into account consistency with a global Paris Agreement pathway.
- Development of transition strategy for LNG industry to renewable hydrogen
- Develop new markets for green hydrogen for a transition away from exporting LNG.

OTHER FOSSIL FUELS



- Effective carbon pricing system
- Regulation to ensure electrification and phasing in of renewable energy.
- Monitoring and regulation for mitigation measures to reduce fugitive emissions.
- Work towards international Agreement for a moratorium for new fossil fuel extraction projects.
- Federal support for a planned regional just transition process with participation of all relevant stakeholders for regions affected by transition.

Figure 9: Overview of emissions levels under different scenarios for different sectors, and policy recommendations.

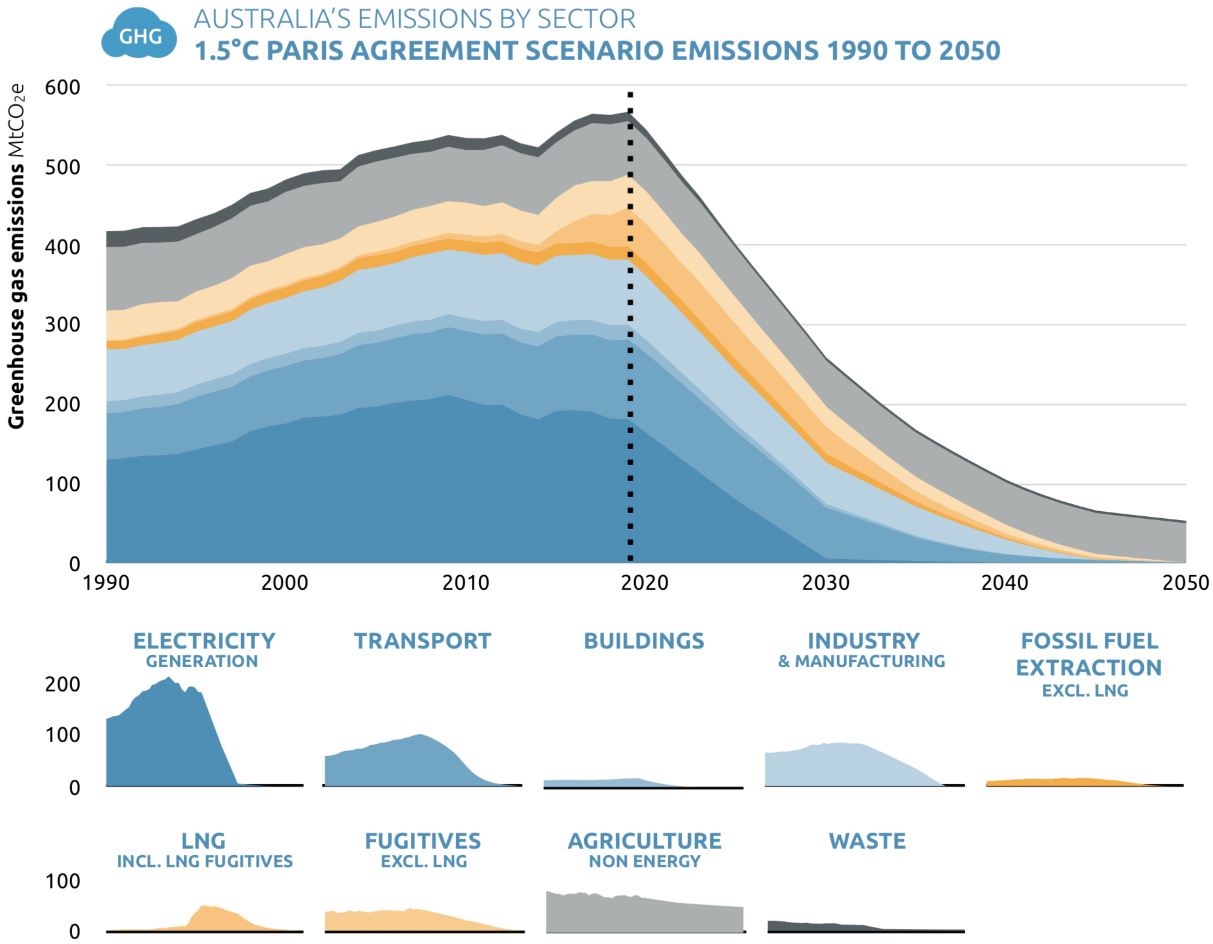


Figure 10 Australia's Paris Agreement-compatible greenhouse gas emissions pathway (not including LULUC) for all of the sectors analysed in this study.

Net zero GHG emissions by 2050 can be achieved by phasing out deforestation by 2030 and maintaining the rate of carbon storage projected for forests by 2030 until 2050 (Figure 11). This would reduce total GHG emissions including LULUCF by 66% below 2005 (Table 3).

Factoring out the non-CO_2 emissions from the land use change and forestry sector, this would have Australia's net-CO_2 emissions reach zero by the late 2030s, with net negative CO_2 emissions prevailing thereafter (see Figure 12 for land use scenarios). If the rate of carbon storage projected for forests by 2030 can be doubled by 2040 net zero GHG emissions would be achieved about ten years earlier in 2040.

The analysis here does not assume offsets between land sector carbon sequestration and greenhouse gas emissions from any other sector. This study also takes into account limits to how much we can rely on increasing carbon removal, as well as inertia in the land sector that limits the available update by 2030, and important trade-offs between a focus on carbon uptake and biodiversity and water values. Policies that focus on carbon storage alone do not generate significant benefits for biodiversity, and policies that favour environment and biodiversity values will result in lower levels of carbon storage. There is a significant trade-off between a focus on carbon uptake and water values, with a high focus on carbon reducing available water significantly.

Building on its extraordinary renewable energy resources as well as essential mineral resources and high skills, Australia can become a regional and international frontrunner in successfully transitioning its energy supply and demand sectors. This will benefit sustainable employment generation, reduce levels of dangerous air pollution, water demand, socially just housing, and new manufacturing value chains and export opportunities based on zero emissions energy carriers including renewable electricity offshore, green hydrogen and energy intensive products such as green steel.

Our findings emphasise that Australia will need to undertake additional mitigation actions in all other remaining non-energy sectors, in particular agriculture and waste, as well as decrease deforestation and sustain a carbon sink in the Land use sector to align its economy-wide emissions pathway with the Paris Agreement's temperature limit and achieve net zero emissions by 2050.

A strategy towards net zero emissions needs to take into account the different starting points, trends and mitigation potential in different sectors (Table 3). Some sectors, such as agriculture, cannot reduce emissions to zero, and others, such as electricity generation, can be rapidly decarbonised. All energy-related emissions can be reduced to zero by 2050, thus minimising the need to rely on carbon dioxide removal of remaining emissions.

The path to get to net zero emissions matters both in terms of the cumulative emissions and their impact on temperature, as well as in terms of the technical and economic transition pathways and policy implications for the near future. This is why targets for 2030 matter: unless governments have believable pathways backed by policies to reduce emission levels, and energy transformations consistent with achieving zero emissions by 2030, then 2050 promises of net zero emissions lack any real credibility.

Sectoral strategies and policies, such as those outlined above, need to be embedded in an overall strategy, ideally with climate legislation to ensure a transparent and effective process to reach consistent overall and sectoral midterm targets.

In summary analysis shows that Australia can reduce overall GHG emissions excluding LULUCF by 90% below 2005 levels by 2050 that net-zero GHG emissions including LULUCF can be achieved in 2050 provided the LULUCF sector is a sink of -53 $MtCO_2e$ or greater by 2050 (Figure 11) or if other carbon dioxide removal options not analysed in this study are introduced.

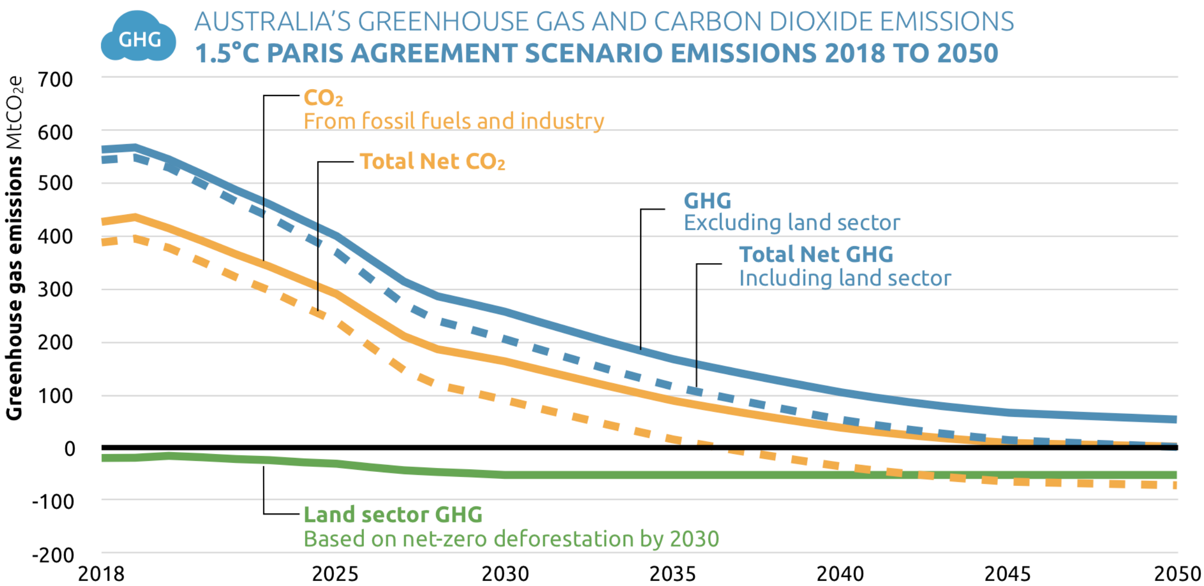


Figure 11 Net greenhouse gas and CO_2 emissions pathway for Australia to reach net zero by 2050.

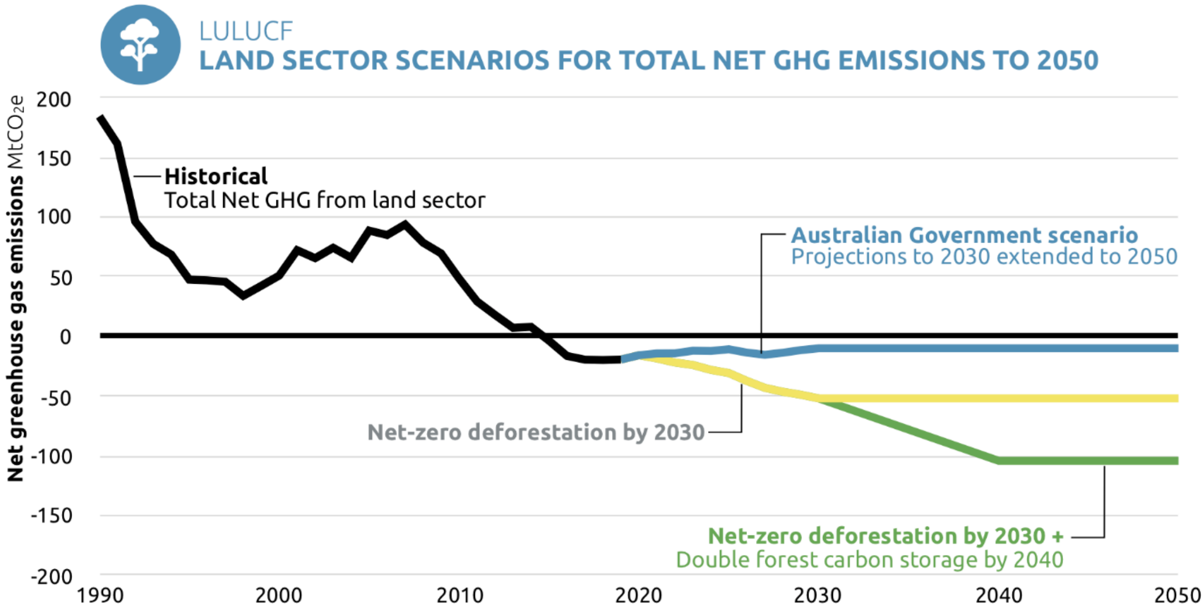


Figure 12 Land use emissions and removals scenarios used in this study.

Carbon budgets and cumulative emissions

Australia's cumulative CO_2 and GHG emissions from this study fit within a range of different perspectives on the carbon and greenhouse gas budgets consistent with limiting warming to 1.5°C. Carbon budgets for warming limits have a very large uncertainty and because of the need for negative CO_2 emissions[1] can be confusing and hard to interpret.

Carbon budgets are subject to very large uncertainties, including first and foremost from non-CO_2 GHG gases. In addition, this kind of budget obscure some key features of the technically and economically feasible pathways of energy system transformation that could meet the 1.5°C warming limit in practice. The CO_2 emissions from 1.5°C compatible scenarios can exceed the carbon budgets identified in IPCC SR1.5 above by 2050, and any excess will have to be compensated for by negative CO_2 emissions post 2050. Part of the reason for this is due to historically high emissions which need to be compensated with negative CO_2 emissions. In addition, ongoing non-CO_2 GHG emissions from hard to abate sectors including agriculture also need to be compensated, so there likely to be a need for negative CO_2 emissions for this purpose.

Two broad perspectives are used here as a cross check on Australia's cumulative emissions.

The IPCC SR1.5 has estimated the remaining carbon budget from 2018 to limit warming, after accounting for an estimated 100 $GtCO_2$ of carbon release from geophysical feedbacks, to below 1.5 °C with 50% chance to be 480 $GtCO_2$ and 320 $GtCO_2$ with a 67% probability (IPCC 2018a). If Australia's share of this were equivalent to its current contribution to global CO_2 emissions of 0.9%[2] its budget would be 2.9-4.3 $GtCO_2$. As this budget corresponds to the time at which 1.5°C is reached this correspond to the period 218-2050 and can be compared with the cumulative Australian total CO_2 emissions from this study of around 2.8 $GtCO_2$ for the same period. It should be noted that the cumulative fossil fuel and industry CO_2 emissions from this study until 2050 are around 5 $GtCO_2$.

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1 To achieve zero emissions there is a need to compensate for remaining emissions using carbon dioxide removal options (CDR), including either large-scale afforestation and reforestation, bioenergy with carbon capture and storage (BECCs) or other options such as direct air capture (DAC). In our analysis, we have not analysed the deployment options for carbon dioxide removal, via BECCs or DAC. We have focused on analyses of options for emission reductions across all sectors with the aim to minimise the reliance on CDR options in the period to 2050. This will also have the benefit of minimising, but not eliminating, the need for CDR options post 2050, a timeframe not considered in this report

2 A broader range of share of global budgets in the literature are explored in the main report.

Whilst on the surface the cumulative Australian CO_2 emissions would appear to be consistent with 1.5°C carbon budget above the picture is more complex due to the ongoing emissions of non-CO_2 GHGs, and the related need for negative CO_2 emissions.

Another way to derive an appropriate greenhouse gas and carbon budget for Australia is to look at the cumulative GHG and CO_2 emissions from 1.5°C compatible scenarios using integrated assessment models (IAM) assessed in the IPCC SR1.5. The full range of emissions including air pollutants are assessed using reduced complexity climate models to produce probabilistic assessment of the global warming consequences to evaluate how these pathways meet the climate goals. This is the way the IPCC SR1.5 evaluated these pathways for 1.5°C compatibility.

The total cumulative global CO_2 budget for limiting warming to 1.5°C based on the integrated assessment model (IAM) scenarios assessed in the IPCC SR1.5 is about 200 $GtCO_2$ for the entire century, and for the period to 2018-2050 about 560 $GtCO_2$. If Australia's share of this were equivalent to its current contribution to global CO_2 emissions of 0.9% its budget would be around 5 $GtCO_2$ to 2050 and about 1.8 $GtCO_2$ for the full century (2018-2100), implying a need for negative CO_2 emissions at scale to compensate post 2050. The cumulative Australian CO_2 emissions from this study from 2018-2050 are around 2.8 $GtCO_2$, which implies a need for ongoing negative CO_2 emissions post 2050.

Looking at fossil fuel and industry CO_2 emissions, the CO_2 budget for limiting warming to 1.5°C based on IAM scenarios assessed in the IPCC SR1.5 is about 350 $GtCO_2$ for the entire century, and for the period to 2018-2050 about 540 $GtCO_2$. This is quite close to the total CO_2 budget above for 2018-2050 as these scenarios generally assume the land sector is close to balance in this period as deforestation is reduced and carbon storage on land is ramped. Post 2050 these budgets diverge as carbon storage on land increases (negative CO_2 emissions) so that the total negative emissions are around 360 $GtCO_2$ with about 190 $GtCO_2$ from measures to take CO_2 from the atmosphere using the energy system, and the remainder in the land sector.

If Australia's share of the fossil fuel and industry CO_2 emissions budget were equivalent to its current contribution to global CO_2 emissions its budget would be around 4.9 $GtCO_2$ to 2050 and about 3.2 $GtCO_2$ for the full century (2018-2100), also implying a need for negative CO_2 emissions at scale post 2050. The cumulative Australian fossil fuel and industry CO_2 emissions from this study until 2050 are around 5 $GtCO_2$, implying a need to be negative CO_2 emissions of order to 2$GtCO_2$ post 2050 to compensate for high historical emissions and for remaining emissions that cannot be reduced to zero.

Finally, for the total global GHG budget for limiting warming to 1.5°C based on IAM scenarios assessed in the IPCC SR1.5 is about 830 $GtCO_2$ for the entire century, and for the period to 2018-2050 about 860 $GtCO_2e$. If Australia's share of this were equivalent its current contribution to global CO_2 emissions its budget would be around 7.7 $GtCO_2e$ to 2050 and about 7.5 $GtCO_2e$ for the full century (2018-2100). Australia's cumulative GHG emissions from this study from 2018-2050 are around 6.4 $GtCO_2e$ (7.8 $GtCO_2e$ before counting land sector carbon storage estimated here at 1.5 $GtCO_2e$). See Table 2 for an overview of these results.

This analysis shows that in general the 1.5°C compatible pathways assessed in the IPCC SR1.5 rely significantly on negative CO_2 emissions to limit warming to 1.5°C or below. The amount of negative emissions ultimately required is linked to near-term emission reduction actions. Higher emissions than should otherwise be the case entail obligations for the future deployment of negative emissions to compensate. The amount of land sector carbon storage assumed in some studies is high and may be infeasible or can raise concerns from a sustainability perspective. Similarly the scale of technologically based negative CO_2 emissions is also large.

What this means for policy is that all efforts need to be taken to minimise the need for negative CO_2 emissions, and this means reducing the cumulative emissions by 2050 as much as possible. Apart from economic costs this is another reason why the substantial emission reductions by 2030 are critical, and hence why the pathway to zero emissions is very important for ultimately achieving the Paris Agreement's long-term temperature goal.

Table 2 Australia's cumulative CO_2 and greenhouse gas emissions for 1.5oC scenario compared to carbon budget estimates

Australia emissions	Scenario emissions 2018-2050	IAM Budget 2018-2050	IAM Budget 2018-2100
Total GHG emissions $GtCO_2e$	6.4	7.7 [6.2–8.5]	7.5 [6.3–8.2]
Fossil fuel and industry CO_2 emissions $GtCO_2$	5.0	4.9 [4.4–5.6]	3.3 [1.7–4.7]
Total CO_2 emissions $GtCO_2$	2.8	5.0 [4.3–5.5]	1.8 [0.9–2.9]
		IPCC SR1.5 budget 2.9–4.3	

Notes: Australia's share of carbon budget assumed here is 0.9%. IAM median budgets are shown and range is [25th – 75th percentile]. The IPCC SR1.5 range is from a 67% (lower budget) to a 50% likelihood (lower carbon budget). It is located in the period to 2050 as the budget is calculate to the point at which the temperature limit is reached and CO_2 emissions reach zero at this time.

Table 3 Sectoral emissions and overall reductions in 2030, 2040, 2050 as compared to 2005 for a Paris Agreement consistent pathway as outlined in this study.

Sector	2005 Baseline	2019 value	2030 reduction compared to 2005 baseline	2040 reduction compared to 2005 baseline	2050 reduction compared to 2005 baseline
Electricity generation	197	180	-97%	-100%	-100%
Buildings	15	19	-69%	-94%	-100%
Transport	80	100	-20%	-87%	-100%
Manufacturing and mining Industry	80	82	-35%	-78%	-100%
Agriculture (non-energy)	76	67	-24%	-30%	-35%
Waste (non-energy)	14	12	-73%	-77%	-78%
Coal mining, Petroleum refining, Oil and Gas extraction (excluding LNG)	15	16	-28%	-84%	-100%
LNG (including fugitive emissions)	4	50	+664%	+14%	-100%
Fugitives from coal, oil and domestic gas	38	41	-31%	-71%	-100%
Total excluding LULUCF	**520**	**567**	**258 (-50%)**	**105 (-80%)**	**53 (-93%)**
LULUCF	**90**	**-19**	**-53**	**-53**	**-53**
Total including LULUCF	**608**	**549**	**105 (66%)**	**53 (91%)**	**0 (100%)**

Note: Totals may not add due to rounding errors

The status of sectoral transitions: opportunities for accelerating climate action

The transitions towards zero-emissions in Australia across sectors have shown very little progress, with the notable exception of electricity generation from renewable energy –despite the attempts by the federal government to stop it.

Progress in the electricity sector was driven by the renewable energy target, which effectively expires in 2020 and will not be replaced. Recent data from the Reserve Bank of Australia that there is a decline in investment in the sector (De Atholia, Flannigan, & Lai, 2020). Australia is lagging behind despite its large opportunities.

Below is an overview of this study's evaluation across all sectors compared with sector-specific benchmarks. These benchmarks represent the most important short-term steps for limiting global warming to 1.5°C identified by the Climate Action Tracker (Kuramochi et al., 2018), as well as more recent analysis of 1.5°C benchmarks based on the scenarios assessed by the IPCC in its Special Report on 1.5°C (Yanguas Parra et al., 2019).

Table 4: Policy Gap Analysis: Sectoral policy activity and gap analysis in Australia across the three largest emitting sectors, electricity, transport and Industry. The 1.5°C compatible benchmarks relate to most important short-term steps for limiting global warming to 1.5°C identified by the Climate Action Tracker (Kuramochi et al., 2018) as well as recent analysis of benchmarks based on IPCC SR 1.5 (Yanguas Parra et al., 2019).

Sector	1.5 °C-consistent benchmark	Australia specific 1.5 °C benchmark	Overall evaluation based on policy activity and gap analysis	Policy rating
Electricity supply sector	*Sustain the global average growth of renewables and other zero and low-carbon power until 2025 to reach 100% by 2050*	*100% renewable electricity generation achieved by 2030s*	• Australia is not on track to meet the benchmark, with government projections indicating renewables will represent just 50% of electricity generation by 2030 if state targets are met. • Australia does not have a renewable energy target beyond 2020. The 2020 target was met, and there has been no new target set (CER, 2019a). • Investment in renewable energy has decreased since 2018 (Clean Energy Council, 2020b). Policy uncertainty and lack of long-term planning of transmission grids is leading to curtailment and delays in grid connections for large scale projects. • Government funding for the national renewable energy agency (ARENA) has decreased and funding is soon to be exhausted (Mazengarb, 2020a). • The government has indicated ARENA's funding will likely continue, but also intends to alter ARENA and the Clean Energy Finance Corporation's (CEFC) remit to be 'technology neutral' and could include coal and gas with carbon capture and storage forcing renewable projects to compete with fossil fuel interests (Mazengarb, 2020d). • Out of the eight states and mainland territories in Australia, six have committed to renewable energy targets and some states have committed to ambitious 100% renewable energy targets. Tasmania plans for 200% renewables.	

Sector	1.5 °C-consistent benchmark	Australia specific 1.5 °C benchmark	Overall evaluation based on policy activity and gap analysis	Policy rating
	No new coal plants, reduce emissions from coal power by at least 30% by 2025	*Phase out coal by 2030*	• There is no plan to phase out coal, which will continue to represent the largest share of electricity generation to 2030 (DEE, 2019a). • The Paris Agreement benchmark of phasing out coal by 2030 would imply an earlier retirement of the fleet of coal fired power stations. • The government has encouraged utilities to extend the lifespan of coal fired power generation beyond the shutdown dates scheduled (Taylor, 2019), generating further investment uncertainty for renewables. • The government continues to incentivise fossil fuel electricity generation, offering incentives through a power subsidy ("Underwriting New Generation Investments") scheme, where a coal generation upgrade has been shortlisted and is likely to be funded (DEE, 2019n; Sydney Morning Herald., 2019a) with additional funding for a feasibility study into a new coal-fired power plant that would require government subsidies. • The Federal Government and New South Wales state government made a deal to supply coal to a coal power station to operate to at least 2042 (RenewEconomy, 2020b).	No Action
Transport sector	*Last fossil fuel car sold before 2035*		• There are no targets to end the sales of fossil fuel cars. The government has announced the development an electric vehicle strategy, but this has not been published (Australian Government, 2019a). • Australia is one of the few countries in the world without any emissions or fuel efficiency standards for light duty vehicles, and the current government has not indicated any intention to introduce these, despite five years of deliberations in the Ministerial Forum on Vehicle Emissions (MFVE). • The current piecemeal policies are ineffective. Recent auctions for the Emissions Reduction Fund have not seen projects in the transport sector. The Safeguard Mechanism only applies to a small portion of transport emissions.	No Action
	Freight trucks need to be almost fully decarbonised by approximately 2050		• Despite the projected increase in road freight transportation emissions (DEE, 2019a), there is an absence of plans to decarbonise freight trucks in Australia. • Unlike the EU, Canada, USA and Japan, Australia has no emissions or fuel efficiency standards for heavy duty vehicles (Climate Analytics, 2019e). • The National Hydrogen Strategy could be used to decarbonise heavy long-range road transport, (plus rail and shipping) if the hydrogen is derived from renewable energy. As the strategy takes a 'technology neutral' approach, this may not be the case.	No Action

Sector	1.5 °C-consistent benchmark	Australia specific 1.5 °C benchmark	Overall evaluation based on policy activity and gap analysis	Policy rating
	Aviation and shipping: Develop and agree on a 1.5°C compatible vision		• Government projections indicate aviation and shipping emissions will increase (DEE, 2019a). • There is no 1.5°C compatible vision or emissions reduction policy for domestic aviation and shipping. • Commitments for reducing emissions of aviation and shipping are limited to international transport through the Carbon Offsetting and Reduction Scheme for International Aviation and as a member of the UN International Maritime Organisation (DFAT, 2019).	
Industry sector	*All new installations in emissions-intensive sectors are low-carbon after 2020, maximise material efficiency*		• The industry sector does not prioritise decarbonisation. Australia's long-term plan to decarbonise the industry sector was abolished with the "carbon tax." • Policies do not ensure low carbon installations nor maximise material efficiency. • Government figures show a decline in emissions in the subsectors of industrial processes, direct combustion and fugitives, despite increases in the past year (DEE, 2019a). • Industrial processes emissions are projected to decline as a consequence of the phase down of hydrofluorocarbons (DEE, 2019a). • Fugitive emissions are projected to decrease (DEE, 2019a), but government figures rely on the Gorgon CCS project to meet its emissions obligations. • There are only a few industry projects in the Emission Reduction Fund portfolio. • ERF and Safeguard Mechanism achieve marginal amounts of emissions abatements (Reputex 2019a). Yet the ERF has been supported with a financial top-up, and renamed the Climate Solutions Fund (CSF). • The federal government takes an increasingly "technology neutral" approach to industry policy without linking it to climate targets in line with the Paris Agreement: - Appointing a Covid-Commission with gas industry stakeholders, which produced recommendations for a gas-led economic recovery (Parkinson, 2020). - Appointing an expert panel with fossil fuel stakeholders to review the ERF/CSF (Australian Government, 2020a, 2020b). - The government intends to change the remit of the CEFC, ARENA and the ERF to take a "technology neutral" approach, and wants to support CCS but not renewable energy (Australian Government, 2020a, 2020b).(Australian Government, 2020c). - The National Hydrogen Strategy is at risk of supporting the fossil fuel industry, as it follows a technology neutral approach. • The National Energy Productivity Plan (NEPP) is not effective, impact policies have not been implemented (Climate Analytics, 2018a). • Australia's LNG related emissions have soared in recent years with large-scale expansion plans.	

Co-benefits of upscaled climate action: employment

Accelerated climate action in Australia can generate significant employment benefits and needs to be a focus for a green recovery out of the economic crisis due to the COVID-19 pandemic.

This study's quantification of employment impacts indicates that the scenario heavily relying on renewable capacity additions supports substantially more jobs compared to the Current Development Scenario driven by the investments into renewable energy and storage technology. Moreover, assuming efforts to increase Australian manufacturing of solar and wind and local sourcing of all related services further increases job prospects considerably.

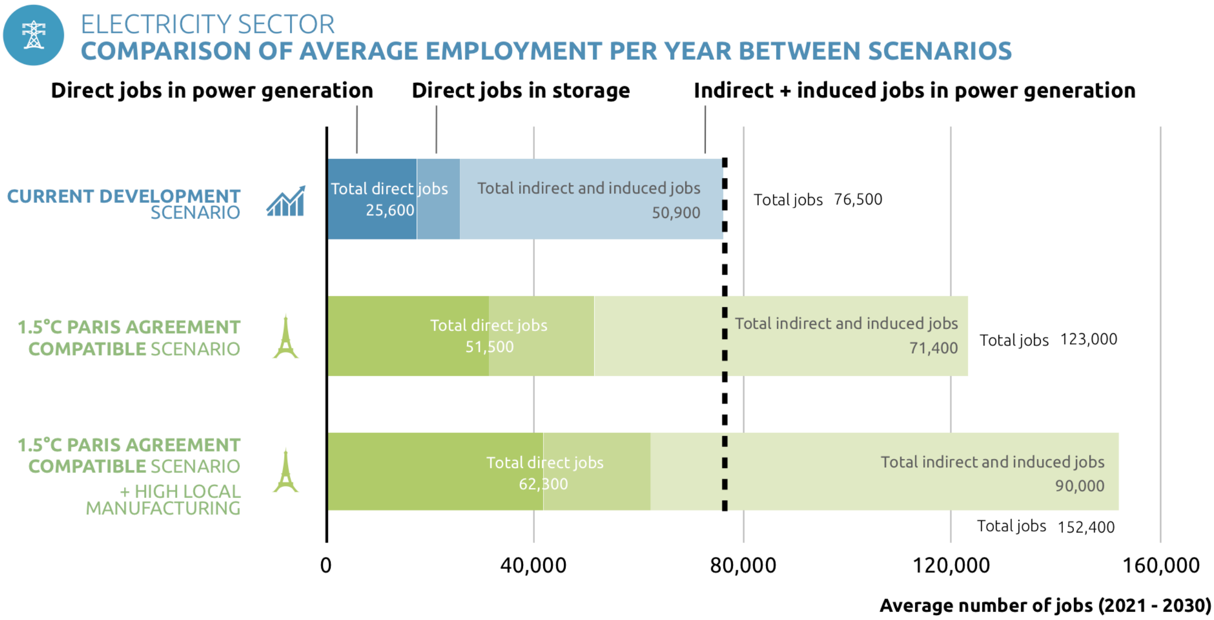

Figure 13: Average direct employment per year between 2021–2030 and average total employment per year between 2021–2030 in Australia for different electricity generation scenarios. Employment impacts related to power generation are estimated with the Economic Impact Model for Electricity Supply (EIM-ES)[3]. Direct jobs related to storage have been approximated based on employment factors from the literature (Ram, Aghahosseini, & Breyer, 2020; Rutovitz, Briggs, Dominish, & Nagrath, 2020) *using approximated storage capacity needs. No indirect jobs related to storage have been estimated. Due to a thinner existing empirical basis regarding storage, the presented numbers for storage are only indicative. Direct jobs include jobs in manufacturing, construction and installation and operation and maintenance. Indirect jobs are jobs further down the supply chain and induced jobs are created by spending of wages throughout the economy. A scenario variant of the Paris Agreement scenario has been added to demonstrate the relevance of local sourcing for local jobs. This PA variant is based on the same emissions pathway and technology mix as the Paris Agreement-compatible Scenario, but it assumes higher shares for local manufacturing of technology components and services being provided within Australia for wind and solar. More information can be found in the methodological annex.*

Under the Current Development Scenario (CDS), approximately 17,000 people per year, on average, are directly employed in the development of new capacity for power generation and the operation and maintenance (O&M) of total capacity (existing and new capacity) over the period between 2021 and 2030. We estimate the investments would stimulate a further 51,000 indirect and induced jobs per year, on average. In addition, over 8,000 jobs related to batteries (distributed and utility scale) and pumped hydro storage (PHS) could be expected in the CDS.

The 1.5°C Paris Agreement-compatible scenarios with accelerated transition to renewable energy have higher employment benefits. Applying the same assumptions on local shares as the CDS scenario supports about 46,000 more jobs compared to the CDS (on average between 2021 and 2030), including about 31,000 direct jobs and 71,000 further indirect and induced jobs in electricity generation stimulated by investments through the supply chain as well as induced economic impacts driven by the spending of wages throughout the economy.

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3 The general EIM-ES tool including a documentation of the tool is available here https://newclimate.org/2018/11/30/eim-es-economic-impact-model-for-electricity-supply/.

The higher storage needs due to the higher share in renewable energy could more than double the number of direct jobs related to storage, mostly batteries (approximately 20,000 jobs per year on average). A variant of the Paris Agreement-compatible scenario, which assumes higher local shares for wind and solar, indicates that efforts to increase Australian manufacturing and local sourcing of services could double total estimated jobs compared to the Current Development Scenario, supporting about 75,000 more jobs, with about 62,000 direct (including storage jobs) and 90,000 indirect and induced jobs.

Employment in electricity supply sector scenarios with accelerated renewables deployment is focused on the construction and manufacturing sectors and increasingly in the development and operation of renewable energy sources, notably solar PV and onshore wind as well as related storage capacities.

These jobs are in technologies and sectors that are more likely to form the core of future electricity supply, both in Australia and globally. Fossil fuel-based jobs do not have a promising future in any of the scenarios. In contrast, jobs related to energy storage could potentially provide large and long-term job opportunities.

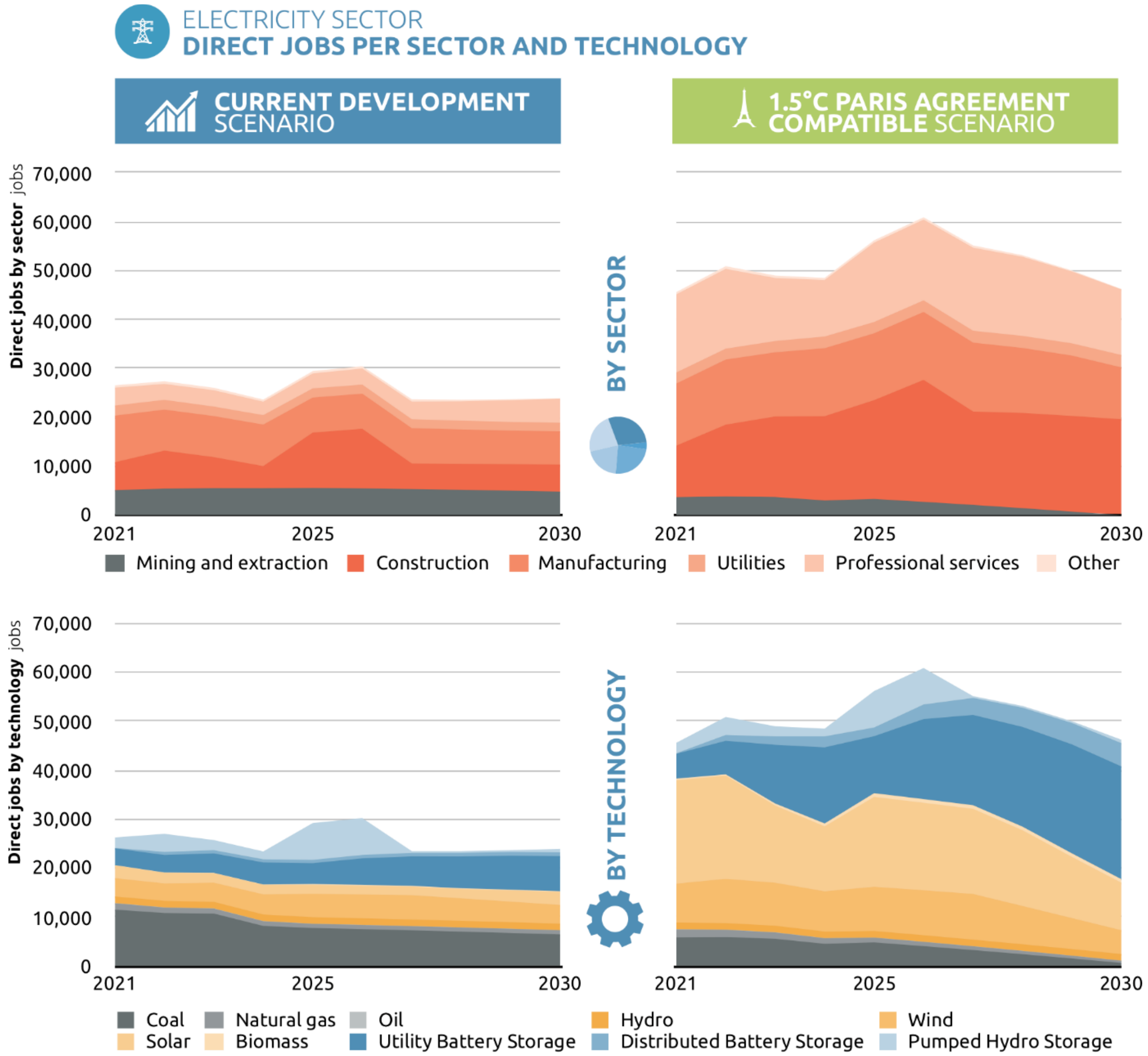

Figure 14: Direct jobs per employment sector' and 'Direct jobs per generation technology' between 2021-2030 for the Current Development Scenario (CDS) (graphs on left) and the 1.5°C Paris Agreement compatible scenario (same assumptions on local shares, graphs on right) for the Australian electricity supply sector Direct employment estimates reflect energy supply sector investments linked to planning, construction, manufacturing of component parts, operation (including fuel supply such as oil and gas production, where relevant) and maintenance of power plants. Note employment impacts for mining and extraction only relate to the fuels used in the Australian electricity supply sector and do not include jobs supported to supply other sectors or the export market. Employment impacts related

to power generation are estimated with the Economic Impact Model for Electricity Supply (EIM-ES)[4], jobs related to storage are approximated based on employment factors from the literature (Ram et al., 2020; Rutovitz et al., 2020), *both based on Input from AUSMOSYS (see methodological annex). Note that the optimization period in AUSMOSYS starts in 2017 with the model suggesting that it would have been optimal to install substantial capacities for wind and solar already in the years before 2021 not shown in this figure, which have however not been installed to this extent in reality. As a consequence, the job impact especially for the Paris Agreement compatible pathway can be considered to even underestimate the job potential in renewable energy for the period shown.*

In the 1.5°C Paris Agreement-compatible scenario, the mining and extraction sector (for local use) accounts for only about 8% of jobs in 2021 and no more jobs in 2030 (see Figure 14, right hand side). Instead, employment opportunities are focused in the construction and manufacturing sectors and increasingly in the development and operation of renewable energy sources, notably, solar PV, onshore wind and hydropower.

The higher number of jobs supported in the construction and manufacturing sectors in the 1.5°C Paris Agreement-compatible scenario by far outweighs the reduction in employment opportunities in the extraction sector, compared to the Current Development Scenario.

The Paris Agreement-compatible scenario assuming higher local shares stimulates the highest local investments in Australia and also supports the highest number of jobs per unit of investment. Both Paris Agreement Scenarios support more jobs per unit of local investment compared to the Current Development Scenario, with the PA scenario with higher local shares showing higher jobs per local investment than the PA scenario with lower local shares.

These findings emphasise how accelerating climate action in the electricity generation sector has the potential to support higher overall employment. They also highlight the need for Australia to prepare a just transition - not only in the electricity sector but across all sectors, to be prepared with skills and jobs for new export opportunities based on the abundant potential for clean energy.

A well-managed transition should start now by reducing the incentives to expand the natural gas sector and building on and increasing opportunities to develop skills in future-proof technologies.

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[4] The general EIM-ES tool including a documentation of the tool is available here https://newclimate.org/2018/11/30/eim-es-economic-impact-model-for-electricity-supply/.

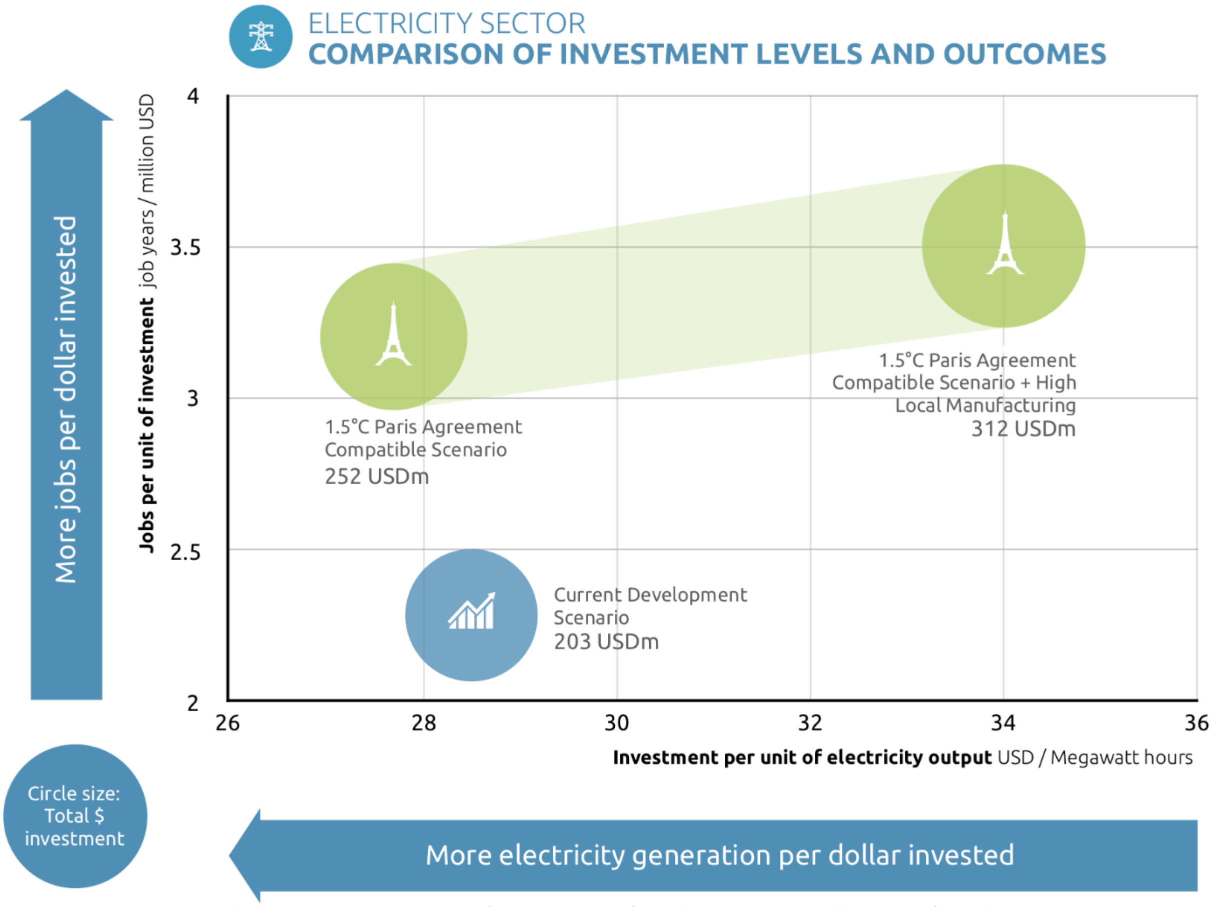

Figure 15: Average job generation per unit of investment (in job years per million USD) and average investment per unit of electricity generation (in USD per MWh) in the Australian electricity supply sector for selected electricity generation scenarios between 2021–2030. Note the figures reported here relate exclusively to investments in Australia and do not reflect the overall cost of scenarios, which also include investments on imported products and services.

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The Climate Action Tracker (CAT) is an independent scientific analysis produced by three research organisations tracking climate action since 2009. We track progress towards the globally agreed aim of holding warming well below 2°C, and pursuing efforts to limit warming to 1.5°C.

The Consortium

NewClimate Institute is a non-profit institute established in 2014. NewClimate Institute supports research and implementation of action against climate change around the globe, covering the topics international climate negotiations, tracking climate action, climate and development, climate finance and carbon market mechanisms. NewClimate Institute aims at connecting up-to-date research with the real world decision making processes.

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Climate Analytics is a non-profit climate science and policy institute based in Berlin, Germany with offices in New York, USA, Lomé, Togo and Perth, Australia, which brings together interdisciplinary expertise in the scientific and policy aspects of climate change. Climate Analytics aims to synthesise and advance scientific knowledge in the area of climate, and by linking scientific and policy analysis provide state-of-the-art solutions to global and national climate change policy challenges.

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