Dexus Climate Scenario Analysis Supplement

Supporting document to Dexus's *Towards Climate Resilience* report

June 2020

Dexus Climate Scenario Analysis Supplement

Dexus's *Towards Climate Resilience* report summarises the outcomes of a climate scenario analysis conducted to assist the business to understand its resilience to climate change and the actions it could take to enhance its preparedness.

The recommendations of the Task Force on Climate-related Financial Disclosures (Task Force) provide more information about the utility of scenario analysis for businesses to understand and address climate-related risks and opportunities.

This *Dexus Climate Scenario Analysis Supplement* provides the assumptions and references that underpin the climate scenarios published in *Towards Climate Resilience*. Dexus worked with the Climate Change and Sustainability services team at EY to construct the climate scenarios and ensure they were supported by comprehensive research. As recommended by the Task Force, the scenarios were designed to be plausible, distinctive, consistent, relevant and challenging.

The *Dexus Climate Scenario Analysis Supplement* provides:

- The scenario pathway development platform (pages 3-4)
- Detailed narratives for each scenario (pages 5-7)
- Assumptions and references that underpin the scenarios (pages 8-11)

Dexus welcomes questions, comments and feedback about its scenario analysis, as well as engagement on its approach to addressing climate-related issues more broadly. If you would like to discuss further, please contact the team at sustainability@dexus.com.

Scenario pathway platform for Dexus's business

To survive in the long-term, companies must anticipate and adapt their business models to meet a range of challenges, including emerging policies, changing market dynamics, structural changes to the economy, growing investor concerns, new and emerging technologies, and the mounting physical impacts of climate change that will affect supply chains, operations and markets.

Whilst climate scenarios cannot predict the future, scenario analysis and pathway development can help organisations to identify and minimise climate risks and maximise climate-related opportunities, supporting the resilience of business in a changing world.

Scenario analysis and planning is an important tool for understanding the potential changes that Dexus may need to adapt to and the key factors which will need to be actively monitored, as well as any measures required to embed climate risk as a material risk alongside other strategic business considerations.

Dexus's scenario pathways

To understand the environment in which Dexus may operate in the future, three climate pathways were developed to support the climate scenario analysis disclosed in *Towards Climate Resilience*. The pathways are based on the Representative Concentration Pathways (RCPs) and the Shared Socioeconomic Pathways (SSPs) published by the Intergovernmental Panel on Climate Change (IPCC), and overlayed with assumptions about the way the world will transform. These assumptions will, and already are, impacting and influencing the future, and could impact Dexus's operating model differently under each pathway.

The Representative Concentration Pathways (RCPs)

The RCPs are established pathways which represent possible future emissions and greenhouse gas concentrations to 2100. There are five pathways which represent specific emission trajectories and different amounts of radiative forcing produced by greenhouse gases.

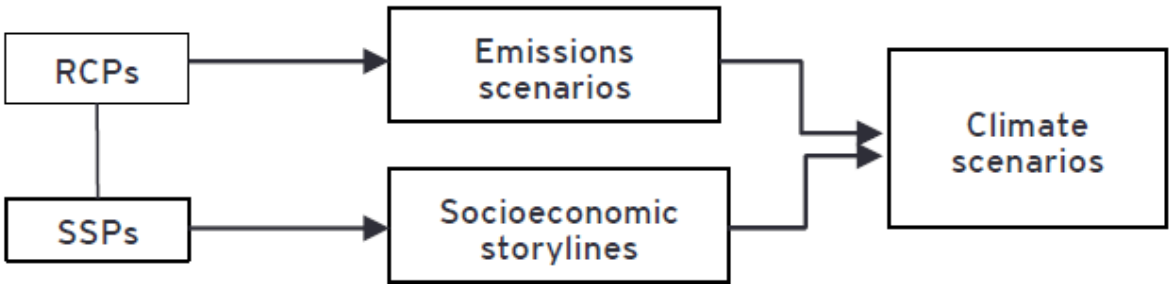
The Shared Socioeconomic Pathways (SSPs)

The SSPs are part of a new scenario framework that the climate change research community has adopted to facilitate the integrated analysis of future climate impacts, vulnerabilities, adaptation and mitigation. They set the stage on which emission reductions will be achieved. The SSPs examine five different ways in which the world might evolve, including aspects of socioeconomic development such as population, economic growth, education, urbanisation and technological development.

These socioeconomic pathways have been designed to be complementary with the RCPs. The SSPs include a baseline which examines emissions under the different socioeconomic pathways in the absence of climate policy and show whether and how different RCPs may be achieved in different socioeconomic contexts.

RCPs and SSPs – a parallel process

By using combined RCPs and SSPs as a platform for its scenarios, Dexus can position itself at the leading edge of thinking in relation to a more holistic approach to scenario analysis. The RCP and SSP frameworks operate in parallel to improve integration of socioeconomic drivers, climate systems and national and human systems, as follows:

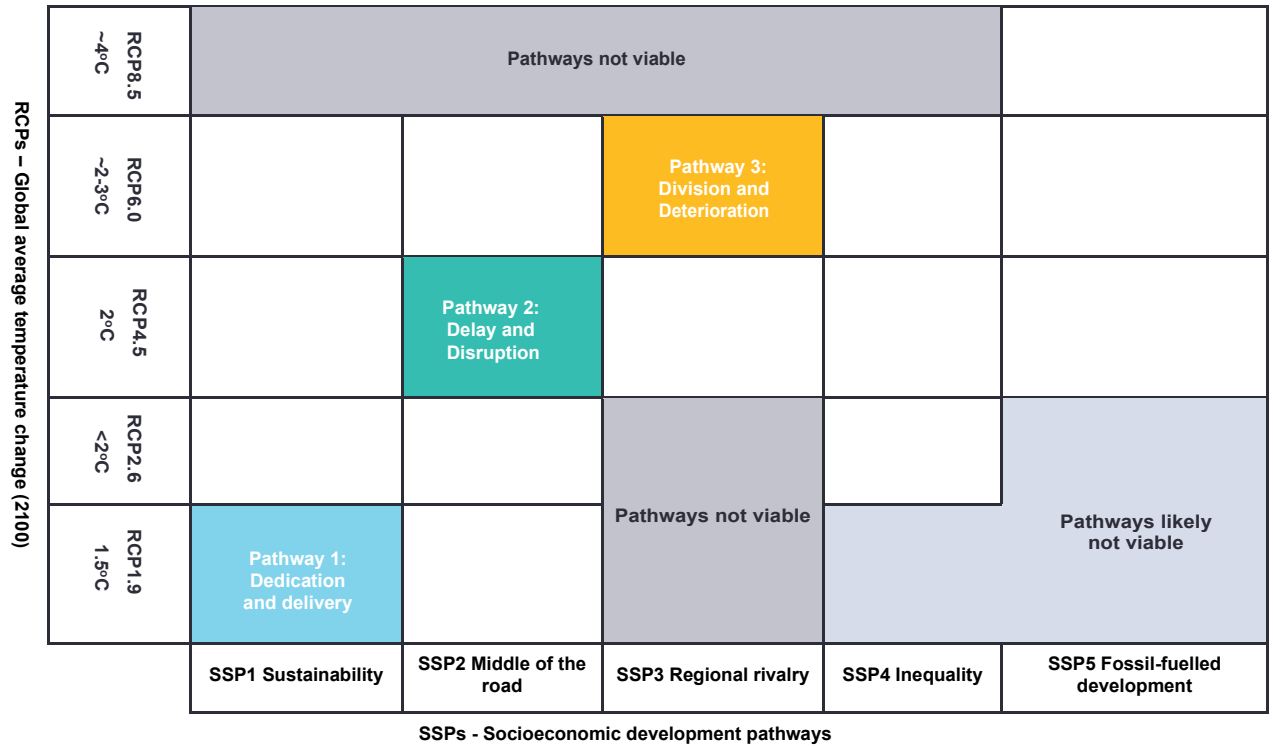


While the RCPs were available in time for the IPCC's 5th Assessment Report, the SSPs were available later and are being used in modelling which will support the IPCC's 6th Assessment Report – expected for release in 2021.

The Dexus climate scenarios are based on three different combinations of temperature change and socioeconomic change shown in the matrix (below), consistent with global scenarios used by the IPCC.

These combinations are overlayed with more detailed assumptions related to factors including technology change, policy change, lifestyle change etc. based on existing literature. The detailed assumptions tailor the scenarios for the Australian context and enable an understanding of plausible futures with direct implications for Dexus.

These pathway combinations have been selected to ensure the scenarios test a range of plausible futures, consistent with best practice guidance for identifying climate-related risks and opportunities.



Pathway 1: Dedication and delivery
Limit warming to below 1.5°C

This pathway represents an emissions trajectory which is broadly in line with the aims of the Paris Agreement, enabling Dexus to test the implications of an extreme (while relatively orderly) transition.

This pathway uses a 1.5°C temperature pathway, combined with a sustainable socioeconomic pathway. A number of published scenarios follow narratives consistent with sustainable socioeconomic development for their 'low emissions' scenario (e.g. Shell-Sky; Arup-Post-Anthropocene). Challenges relating to decarbonisation and adaptation to physical climate impacts are low for this pathway.

Pathway 2: Delay and disruption
More likely than not to exceed 2°C

This pathway is broadly based on a business as usual pathway where current trends continue. The socioeconomic development pathway of 'Middle of the Road' is combined with a climate pathway of more than likely not to exceed 2°C, as it presents medium challenges to decarbonisation and adaptation to physical climate impacts. A number of other published scenarios based on this temperature change have used a similar socioeconomic narrative (e.g. Arup-Humans Inc. IEA STEPS).

This pathway will integrate a shock (e.g. the PRI's Inevitable Policy Response), reflecting the extreme decarbonisation effort that would be required at a later date.

Pathway 3: Division and deterioration
Likely to exceed 2°C

This pathway will enable Dexus to explore the implications of the most significant climate impacts, as well as the high challenges to mitigation and adaptation. This pathway applies a more pessimistic climate impact scenario (likely to exceed 2°C), in combination with a socioeconomic pathway of regional rivalry. This narrative has been explored in other published scenarios (e.g. Arup-Extinction Express).

Pathway 1: Dedication and delivery

Climate and socioeconomic scenarios used:

- Sustainability – Taking the Green Road (SSP1)
- Climate pathway focused on limiting warming to below 1.5°C by 2100 (RCP1.9)

Pathway 1 is a world where …

The global community urgently recognises the need to address climate change through collective decarbonisation. A global systems change is achieved through a point of agreement between politics, corporations and society at a macro level. Challenges to decarbonisation and adapting to climate impacts will be low, as the world collectively shifts in the direction of a more sustainable future. Consideration of economic growth broadens to include a focus on human well-being. This scenario would see a dramatic economy-wide transition requiring businesses to rethink how they provide value, and how to amplify their contribution to remain influential within their industry. Through prioritisation of alignment between planetary boundaries, economic growth and democracy, the world achieves equality both across nation-states, and inter-generationally.

…the policy environment is focused on strong emission reduction pathways

- The Paris Agreement is prioritised globally, where countries submit their third round of climate pledges (national targets) in 2025, and policy responses and commitments accelerate.
- Australia commits to ratchet up ambition from the current 2030 national target of 26-28% reductions in emissions on 2005 levels to a more aggressive emissions reduction target, and State-based targets are withdrawn to collectively prioritise this, which we achieve.
- Australia effectively implements an economy-wide carbon pricing mechanism, which may be linked to other schemes internationally. A carbon price under this pathway would be approx. US$300 / tCO2e in 2030, US$650 / tCO2e in 2050 and US$238 / tCO2e in 2100 (IIASA).

…electricity comes from diverse sources on a distributed network…

- With 45% of capacity from decentralised sources by 2050 (AEMO, 2019), a combination of renewable energy zones, small scale renewables, electric vehicles, battery storage and virtual power plants will act in concert, potentially with peer to peer energy trading.

…the role of buildings will evolve within sustainable cities as our population reaches nearly 43 million by 2050

- **Property companies will be service providers:** high energy efficiency standards, demand response solutions and small-scale renewables, enable buildings to be consumers, storage points and generators of energy (e.g. batteries in carparks and investment in microgrids). As electricity becomes the primary fuel for land-based transport (IEA, B2Ds, 2017), charging stations will be a critical component of the built environment.
- **Property companies will be service providers:** mass urbanisation and the drive for resource efficiency will see property companies orienting towards ‘space as a service’. Cradle-to-cradle design philosophy, considering energy provision, waste recycling, access to technology (hardware and software) and fit outs will be standard inclusions to close the loop across materials, energy, waste and water over the building lifecycle. Technology enables direct engagement, co-design of spaces and tailored, augmented/virtual reality experiences.
- **Property companies will create value through coordinating economic activity:** the value of the built environment will be pioneered by the companies who can coordinate transport, buildings, utilities and data (as Uber did for the private car sector). Traditional, passive landlords will be at risk of disintermediation and ultimately, commoditisation.

…emerging and declining markets will change the landscape of leaders in the economy

- Global emissions will peak in the 2020s, and decline to zero by 2050, with negative emissions from approximately 2045-2055 (IPCC, 2019).
- Rapid global decarbonisation efforts will see further coal export/import restrictions, slowing the growth of the coal export sector within Asia Pacific. Coal will cease to exist as a primary energy source by 2050.
- As the fossil fuel industry declines, its service providers will be at risk of financial loss, while new opportunities will exist in emerging markets. For example, banks will divest from fossil fuels and prioritise future- focused sectors (such as renewables), with favourable terms.

Pathway 2: Delay and disruption

Climate and socioeconomic scenarios used:

- Middle of the road (SSP2)
- Principles for Responsible Investment: Inevitable Policy Response
- Climate pathway more likely than not to exceed 2°C by 2100 (RCP4.5)

Pathway 2 is a world where …

Humanity continues to follow the current trajectory in the near term, with a sudden change in policies from around 2025 as nations submit their 3rd round of climate pledges (NDCs). This initiates a medium-term Forecast Policy Scenario (FPS) covering all sectors with a particular focus on electricity, transportation and agriculture and lays the foundation for a longer term trend constrained pathway out to 2100 (PRI, 2019).

Today, four of the nine four of the nine planetary boundaries have already been crossed (climate change, loss of biosphere integrity, land-system change and altered biogeochemical cycles). The defining features of this pathway are continued global ecosystem disruption and uneven economic development, driven by current policy constraints and slowing social, economic and technological trends.

The pressure will grow for business leaders to act – especially from grassroots activism led by younger people. Coupled with continued escalation of climate impacts, this will result in a potential late policy shift, which will require industry to adapt quickly.

…in the near-term, climate policy progresses, although lack of ambition and a disjointed approach limits its effectiveness

- The Paris Agreement remains the key international driver of emissions reductions, with countries broadly achieving current national targets. However, policies remain disjointed and are not sufficient to hold warming below two degrees.

…the risk of inaction will be amplified by a late 'shock'

- Aggressive policy shifts are expected in around 2025, as Governments are forced to act more decisively in third round of national climate pledges under the Paris Agreement's 'ratchet mechanism.'

A 'shock' will then occur between 2025 and 2030 as markets respond to these aggressive targets and national policies are established.

- There is potential for a significant period of transition risk which is not priced into today's markets (PRI, 2019), resulting from continued policy and technology shifts between 2030-2050.
- Policy changes during this period could drive: coal-phase outs; increased energy efficiency, renewable energy and carbon capture and storage; and agriculture and land use-based GHG removal. The longer the delay, the more disorderly, disruptive and abrupt the change will be.
- Since investment in high emission industries continues as business as usual until the point of shock, there will be no time to divest, or divert capital connected to these industries. Post-shock, when a two degree target is taken seriously, assets will be 'stranded', becoming devalued and requiring premature write-off (Institute for New Economic Thinking, Oxford University). When the 'carbon bubble' bursts due to policy shock it could lead to a global wealth loss of between $US1 – 4 trillion - comparable to the 2008 financial crisis (King et al., 2017). Assets which are inefficient or in regions where the economy is supported by the fossil fuel industry, will be most at risk.
- The shock will bring high costs associated with compulsory retrofits of buildings and precincts which do not meet policy requirements.
- Under a late shock scenario an emissions price will be approximately $US40-60/tCO2e in 2030, and >$US100 tCO2e in 2050 (PRI).

…early adopters will be rewarded

- Prior to the shock, the current trajectory will not incentivise climate resilience of communities, precincts and buildings. However, post-shock, early adopters will be equipped to make necessary minor adjustments, as opposed to disruption of the operating model at huge expense.
- Early adoption of energy efficient technologies and emerging energy procurement solutions are among a range of strategic business decision to be considered given the potential rate of decline in coal as primary energy source and increasing stringency of energy efficiency regulations.

Pathway 3: Division and deterioration

Climate and socioeconomic scenarios used:

- Regional rivalry – A rocky road (SSP3)
- Climate pathway that is likely to exceed 2°C by 2100 (RCP6.0)

Pathway 3 is a world where …

Humanity will continue to utilise natural resources as we do today, resulting in a continuous increase of the energy imbalance to 2100, and continuous global warming towards the end of the 25th Century.

Slow economic growth will be coupled with a resurgence of nationalism due to fears of national security, and an attitude of individualism. In this pathway, climate changes will cause societal deterioration, which will lead to further climate deterioration, and this will continue as a vicious cycle.

Breakdown of climate systems could trigger breakdowns of human systems, resulting in the process of a collapse in which economic, social and political destabilisation is felt through the globally linked system.

The growing disconnect with the global community could see increased tensions and fracturing relationships, resulting in an even less globalised world. With a growing global population, "Lifeboat Ethics" will become even more front of mind in relation to the role of wealthier nations, such as Australia, to support poorer nations, and how resources are to be distributed. In a world with global distrust, and an unwillingness for nations to cooperate, instability and nationalism will only emphasise inequality.

…policy fails and there is little response to a changing climate

- Australia's 'go-slow' approach to international climate negotiations will become the norm globally, as sustainability is not seen as a priority.
- The Paris Agreement fails as major economies withdraw. Growing disconnect between regions equates to fragmented policies and little response to changing climate. The Australian 2030 national target is not achieved.
- As regions become more disconnected, and climate change is deprioritised, there is no incentive for Australian States to achieve targets, and there will be disparity between State-based commitments which remain in place.

…the physical impacts of climate change will be severe in Australia

- In a 2°C world there will be a 77% likelihood of annual severe heatwaves, power blackouts and bushfires (compared to pre-industrial) (King et al., 2017). Further, extreme rainfall events (wettest day of the year and wettest day in 20 years) will increase in intensity, and a higher proportion of rainfall will come from extreme events, even in regions where total rainfall is expected to decrease (Buckley et al., 2019).

The role of the buildings sector will evolve as a haven for the community as people increasingly require shelter from higher temperatures, extreme weather events and poor air quality.

…corporate action on climate change is deprioritised

- With little or no incentive for businesses to curb emissions, climate change is deprioritised. However, climate activism from citizens and investors grows, with increasing angst about the inaction from political and business leaders. Corporates are increasingly expected to act on their own, without meaningful policy frameworks, public incentives, or best practice guidelines.

…global supply chains could be threatened

- As national security takes priority and global relationships are fractured, there is a risk that supply chains could be threatened. Trade relationships could break down, requiring new pathways and partnerships in the form of bilateral agreements over free trade. The physical impacts of climate change may also disrupt global supply chains, impacting business activities across a multitude of sectors.

…national security and nationalism surges, creating a new type of demography

- As people are displaced by climate impacts, mass migration and urbanisation is amplified, advanced economies are net importers of people, and rural population declines, including within Australia. It is estimated that by 2050 between 665,000 to 1,725,000 people are predicted to be displaced in the Indo-Pacific region as a result of environmental change (Lowy Institute).
- There are growing conflicts, both trade and military, fuelled by 'environmental concerns' and trade protectionism, negatively impacting the economic prosperity of individual states.

Assumptions

The following assumptions have been curated to consider key levers of social, economic and environmental value that are relevant for the pathways. The table below shows how the assumptions interact with each pathway, which have informed discussion on how these pathways may impact Dexus's business.

	Pathway 1	Pathway 2	Pathway 3
International policy			
International carbon commitments	The Paris Agreement is strengthened, and countries submit their third round of climate pledges (NDCs) in 2025. Policy response and commitments to accelerate. (PRI, 2019). Net zero emissions achieved globally by 2050 (IPCC, 2019).	The Paris Agreement targets are met but insufficient. Rapid policy action over the next decade leads to a radical policy and technology shift which continues out to 2100. Potential for large period of transition risk beyond next 10-15 years (PRI, 2019).	The Paris Agreement fails as major economies withdraw. Growing disconnect between regions equates to fragmented policies and little response to changing climate.
Primary energy 2050 – coal (EJ/y)	Demand for coal as a primary energy source plummets in the early 2020s, falling from 141EJ in 2020 to 24.63EJ in 2050 (IIASA 2020 SSP database). Rapid global decarbonisation and rejection of traditional coal-fired primary energy (both thermal and for steel) sees Australia's coal export industry capitulate.	Phase-out of coal for electricity by 2030 in Australia and Japan; and 2045 in China and South Korea cause a rapid decline in Australia's thermal coal exports.	Coal as primary energy source gradually increases through to 2030. Following this, demand fluctuates, possibly due to breakdown of key trade deals, volatile economic outcomes or increased migration and conflict. Usage rises to 163.36EJ at 2050 (IIASA 2020 SSP database).
Domestic policy			
Australian carbon reduction commitments and policy	Australia achieves more ambitious reductions than the current 2030 Nationally Determined Contribution (NDC) target of 26-28% reduction in emissions on 2005 levels. An Australian emissions pricing mechanism is developed (2023-2028), with possible linking to regional schemes (e.g. New Zealand, China). A strong pathway for decarbonisation ensues.	The current 2030 NDC target is achieved, however, this target is not consistent with holding warming below 2 degrees. Policy shock to occur around 2025 due to domestic public demand, international pressure and OECD warnings that targets and policies are insufficient.	The 2030 NDC is not achieved, global commitment to the Paris Agreement deteriorates and nationalism surges. Effective national policy for carbon reduction does not emerge.
State-based carbon reduction commitments	State level targets are gradually withdrawn, and as national targets and effective national policy is implemented.	States achieve their commitments due to a policy shock around 2025 with potential for later ratchetting up. An uncoordinated approach limits effectiveness overall.	As regions become more disconnected, and climate change is deprioritised, there is no incentive for States to achieve targets.
Buildings, energy and transport			
Building Code	To be consistent with a 1.5˚C trajectory, 4, 5 and 6 Star Green Star buildings would be required to achieve net zero emissions by 2027, 2024 and 2021 respectively (GBCA, 2017).	Current core building policies by the Federal Government remain intact, with increased stringency over the coming decade. Key policies include: energy efficiency disclosure under Commercial Building Disclosure (CBD) regulation, similar energy efficiency standards for NABERS rating system, continued commitment to the NDC (EY, 2019). Retrofitting costs may be exacerbated for late movers that have not prepared a more stringent policy.	No changes to current Building Code requirements with minimal expansion of voluntary building rating systems such as NABERS.

	Pathway 1	Pathway 2	Pathway 3
Buildings, energy and transport (cont'd) Energy efficiency	Feasible yet ambitious future standards for buildings and equipment drive greater energy efficiency, leading to approximately 38,000 GWh energy efficiency savings by 2039 in Australia (on 2019 level) (AEMO, 2019). By end of 2025-26, there is an average annual reduction rate of 1.4% forecast in residential electricity demand (AEMO, 2019). Annual investment in low carbon electricity supply and energy efficiency in transport, industry and buildings are expected to rise by about USD 160-200 billion by 2029 in RCP1.9-RCP2.6 scenarios (IPCC AR5, 2014). Nearly 75% of today's electricity demand for buildings could be saved by 2030 through improved efficiencies such as heat pumps, solar thermal, energy-efficient district energy solutions, building envelope improvements (IEA B2DS, 2017).	Approx. 24,000 GWh energy efficiency savings by 2039 - AUS (AEMO, 2019) with an expansion of energy efficiency policy including energy efficiency certificate trading schemes and the introduction of a carbon pricing mechanism.	Slow economic and population growth contributes to reduced drive for more efficient energy R&D and deployment, resulting in around 19,000 GWh energy efficiency savings by 2039, half of the savings experienced in Pathway 1 (AEMO, 2019). Forecast average annual growth rate of 0.3% for residential electricity demand to 2025-26 under business as usual (AEMO, 2019).
Renewable energy uptake	Rapid uptake from 2020 onwards. Approximately 34,000 MW installed NEM rooftop solar PV capacity by 2038 (AEMO, 2019). Approximately 90% of houses installed. The 2019 Government Energy Statement for 2017-18 had generation as 60% coal, 23% oil and gas, 6% hydro, 6% wind, 4% solar PV and 1% bioenergy (DoEE, 2019). In Australia, the electricity mix is forecast to be approximately 70% by 2030 (38% solar PV, 20% wind), >90% by 2040 (>45% solar PV, 25% wind) over >99% renewables by 2050 (>50% solar PV, 30% wind) (CSIRO, 2019). Large-scale battery build costs are forecast to reach $1480/kW by 2030, $1442/kW by 2040 and $1433/kW by 2050 (AEMO, 2019) compared to approximately $2040/kW now. Large-scale PV build costs are forecast to reach $817/kW by 2030 and $579/kW by 2050 compared to black coal which are forecast to reach $3246/kW by 2030 and $3143/kW (AEMO, 2019). Coal build costs are not forecast to differ between pathways 1 and 2. Installed battery power for the NEM reaches approximately 6000MW in 2039, around double the capacity in Pathway 2 and compared to 250MW presently (AEMO, 2019).	Uptake continues in the 2020s (though at a slightly slower rate) due to network congestion and easing retail prices as new large-scale renewable generation comes online. Approximately 21,000 MW installed NEM rooftop solar PV capacity by 2038 (AEMO, 2019), on 60% of residential buildings. The 2019 Government Energy Statement for 2017-18 had generation as 60% coal, 23% oil and gas, 6% hydro, 6% wind, 4% solar PV and 1 % bioenergy (DoEE, 2019). In Australia, the proportion of renewable energy in the electricity mix is forecast to be approximately 50% by 2030 (35% solar PV, 12% wind), 75% by 2040 (45% solar PV, 25% wind) over 90% renewables by 2050 (>45% solar PV, ~28% wind) (CSIRO, 2019). Large-scale battery build costs are forecast to reach $1390/kW by 2030, $1343/kW by 2040 and $1340/kW by 2050 (AEMO, 2019) compared to approximately $2040/kW now. Large-scale PV build costs are forecast to reach $832/kW by 2030 and $543/kW by 2050 compared to black coal which are forecast to reach $3246/kW by 2030 and $3143/kW (AEMO, 2019). Coal build costs are not forecast to differ between pathways 1 and 2. Installed battery power for the NEM reaching approximately 3000MW in 2039, up from approx. 250MW in 2019-20 (AEMO, 2019).	No significant increase in renewable energy investment from the present day. The 2019 Government Energy Statement for 2017-18 had generation as 60% coal, 23% oil and gas, 6% hydro, 6% wind, 4% solar PV and 1 % bioenergy (DoEE, 2019). Slow but continual uptake, reaching approximately 15,000 MW installed NEM rooftop solar PV capacity by 2038 (AEMO, 2019), on 40% of residential buildings installed.

	Pathway 1	Pathway 2	Pathway 3
Buildings, energy and transport (cont'd) Electric vehicle uptake	Electric vehicles could account for 90% of all cars and commercial light vehicles in Australia by 2050 (Renew Economy, 2018; ARENA, 2018), permitting the right combination of policy incentives, infrastructure and an approximate $1.7 billion in private investment.	Sales bans on the internal combustion engine for light duty vehicle by 2040 and heavy-duty vehicle by 2045.	Low electrification (10% of total transport) by 2100 (Fricko et al., 2017
Climate impact			
Average temperature increase	Temperatures in Australia to stay well below 2°C, peaking around 2050 (CSIRO, 2019).	Australian average daily maximum temperatures are expected to rise by ~1.6-2.9°C (mean ~2.2°C) by 2080-2099 (CSIRO & BOM, 2015).	Australian average daily maximum temperatures are expected to rise by ~3.1-5.5°C (mean ~4.3°C) by 2080- 2099 (CSIRO & BOM, 2015).
Peak temperature	Assumption not available.	Australian peak temperatures are expected to rise by ~1.7-3.2°C (mean ~2.4°C) by 2080-2099 (CSIRO & BOM, 2015).	Australian peak temperatures are expected to increase by 2.5-5.6°C (mean ~4.1°C) by 2080-2099 (CSIRO & BOM, 2015).
Rainfall events	Assumptions not available.	Annual rainfall in Eastern Australia is expected to decrease by 7% by 2090 (CSIRO & BOM, 2015). Extreme precipitation short-duration (hourly) events in Australia are expected to increase at a higher than 7% rate of change (CSIRO, 2019) going forward out to around 2050.	Annual rainfall in Eastern Australia is expected to decrease by 10% by 2090 (CSIRO & BOM, 2015). Impacts of intense short duration rainfall are expected to be severe. Potentially 40% increase for annual maximum extreme (single day) rainfall intensity (Buckley et al., 2019 by 2050.
Population Australia (Million) – 2050	42.636 (IIASA 2020 SSP database)	41.973 (IIASA 2020 SSP database)	33.477 (IIASA 2020 SSP database)
Population Global (billion) - 2050	8.53 (IIASA 2020 SSP database)	9.16 (IIASA 2020 SSP database)	9.95 (IIASA 2020 SSP database)
GDP (Purchasing power parity) (billion US$2005/yr) – 2050	2740.671 (IIASA 2020 SSP database)	2390.903 (IIASA 2020 SSP database)	1757.554 (IIASA 2020 SSP database)
Migration	Although rising temperatures are limited to 1.5°C, food and water insecurity remains one of the largest challenges on the global agenda. However, improved global collaboration and greater equity across the world results in a united effort to relieve the most resource-stressed regions. As a result, projected migration and displacement patterns are lessened.	Increased global temperatures lead to growing issues including prolonged drought, crop failure, water scarcity. These issues are particularly felt in South-East Asia and the North Africa and Middle East (MENA) regions (Cribb, 2019). As a result, forced migration increases throughout the 21st century.	Population growth is rapid. Prolonged droughts result in food insecurity in many global regions. Concurrently, depletion of groundwater aquifers in vulnerable regions such as Sub-Saharan Africa, South Asia and Latin America leads to 140 million 'climate refugees' by 2050 (World Bank, 2018). It is estimated that by 2050 between 665,000 to 1,725,000 people are predicted to be displaced in the Indo- Pacific region as a result of environmental change (Lowy Institute). Australia's visa restrictions become increasingly stringent.
Emissions			
Emissions prices (US$/tCO2)	A carbon price under this pathway would be approximately US$300/tCO2e in 2030, US$650/tCO2e in 2050 and US$238/tCO2e in 2100 (IIASA, 2020).	Border carbon adjustments expected to play a key role. Carbon price projected to be in the range of $US40/tCO2e (IPR) by 2030 with international convergence to $US100 by 2040.	Carbon prices slowly increases, however only reaching approx. 50-100 US$/tCO2. (Fujimori et al., 2017).
GDP losses rate due to climate policy (%/yr)	Approx. 1.5% by 2100 (Fujimori et al., 2017)	Approx. 1.0% by 2100 (Fujimori et al., 2017)	Approx. 3.2% by 2100 (Fujimori et al., 2017)

	Pathway 1	Pathway 2	Pathway 3
Land use			
Extent of built up areas (million ha)	2020: 35.805 2050: 52.274 (IIASA SSP database)	No data available.	2020: 35.805 2050: 42.074 (IIASA SSP database)

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