PATHWAYS TO NET ZERO EMISSIONS

PREPARED BY KINESIS FOR
THE GREATER SYDNEY COMMISSION

AN ANALYSIS OF EMISSION REDUCTION PATHWAYS FOR GREATER SYDNEY
MARCH 2022

Note: This report is provided subject to some important assumptions and qualifications:

The results presented in this report are modelled estimates using mathematical calculations. The data, information and scenarios presented in this report have not been separately confirmed or verified. Accordingly, the results should be considered to be preliminary in nature and subject to such confirmation and verification.

Energy, water and greenhouse consumption estimates are based on local climate and utility data available to the consultant at the time of the report. These consumption demands are, where necessary, quantified in terms of primary energy and water consumptions using manufacturer's data and scientific principles.

The Kinesis software tool and results generated by it are not intended to be used as the sole or primary basis for making investment or financial decisions (including carbon credit trading decisions). Accordingly, the results set out in this report should not be relied on as the sole or primary source of information applicable to such decisions.

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1. EXECUTIVE SUMMARY

Achieving the net zero aspirations for NSW will require significant interventions across Greater Sydney.

Greenhouse gas emissions associated with Greater Sydney residents and businesses, contribute to over one third of NSW's total greenhouse gas emissions[1]. Greater Sydney will therefore be required to take a lead role in delivering net zero emissions across NSW by 2050 or sooner.

In 2017, the Greater Sydney Commission released the *Exploring Net Zero Emissions for Greater Sydney* report which found that:

1. Land use, transport and infrastructure planning interventions in Greater Sydney play a significant role in reducing greenhouse gas emissions.

2. Placed-based interventions that respond to local land use, infrastructure and transport patterns are required to deliver emission reductions.

The report enabled the inclusion of emission reduction objectives within the *Greater Sydney Region Plan* and *District Plans* released in 2018, including the inclusion of the objective to support the delivery of the state's net zero emissions by 2050 objective.

Over the last three years, the NSW Government has released a series of policy programs and technology strategies that have implications for emissions reduction in Greater Sydney and across NSW. The most notable of these being the Net Zero Plan Stage 1: 2020-30 ("NSW Net Zero Plan"), which include a target of net zero emissions by 2050. This will require action in all locations across NSW, by all industry sectors, Government agencies and the community.

The main purpose of this study is to engage with key stakeholders across NSW Government to incorporate their technical input and policy advice to better understand:

- The greenhouse gas emissions impact on Greater Sydney of the NSW Net Zero Plan and other relevant NSW policy, programs including the Future Transport 2061 plan; and

- Beyond the timeframe of these current policies (generally beyond 2030), what will be required for Greater Sydney to support NSW reaching net zero emissions by 2050 or sooner.

A range of emission reduction scenarios were developed to demonstrate how Greater Sydney could support the NSW Net Zero Plan by achieving net zero emissions by 2050 or sooner:

1. **2021 Policy Settings** which reflects current NSW Government policy settings as well as expected technology adoption as referenced from available, published reports.

2. **Managed Future Transition** which extends the relevant NSW Government policy settings and seeks to deliver a level of decarbonisation that may be reasonably expected based on recent local trends and moderate level of ambition.

3. **Accelerated Future Transition** which represents an ambitious scenario of emissions reduction and the potential to achieve net zero emissions earlier than 2050. This is based on an accelerated take up of existing and new zero emission technologies and behaviors in Greater Sydney supported by NSW policies, planning frameworks and programs.

The scenarios explored in this report reflect different anticipated policy and technological outcomes and as such, have varying implications for social and economic costs and benefits. At a global scale, studies have shown that the economic implications are significant. The probable savings (avoided damages) from keeping global warming to a 1.5°C rise, relative to a 2°C rise, are a cumulative US$20-trillion increase in world GDP by the end of the century. These implications, both positive and negative, trickle down to Greater Sydney. While this report identifies these impacts and opportunities, further analysis is needed to quantify the costs and benefits of specific interventions, policies and programs.

Scenario Analysis Findings

The scenarios simulate the varying roles and timing of state and federal government policy and technology interventions to drive emission reductions in Greater Sydney. They have been developed through independent research, stakeholder input and professional opinion. The implications of this analysis are as follows:

- Building on existing policies and programs, accelerated decarbonisation is required to ensure Greater Sydney achieves net zero emissions on or before 2050 without the requirement for significant offsets.

- Decarbonising electricity through the closure of Coal Fired powerplants, replacement grid scale renewables and rooftop solar uptake is the most significant intervention across all scenarios.

- Select interventions explored in this study may have a small impact on emissions reduction but have important secondary benefits including placemaking, climate resilience, cost of living and reduced congestion For example, building efficiencies play an important role in the short term (until around 2030) before significant electricity decarbonisation occurs, but play an ongoing benefit in reducing operating costs for residents and tenants.

[1] Exploring Net Zero Emissions for Greater Sydney (2017) https://gsc-public-1.s3.amazonaws.com/s3fs-public/exploring_net_zero_emissions_for_greater_sydney_-_kinesis_-_october_2017.pdf

- Electrification, including electric vehicles, plays a vital role in emission reduction and has a growing impact once electricity decarbonises.
- The urban form characteristics of Greater Sydney, particularly future employment distribution and interconnectedness of centres influenced by planning reforms, infrastructure investment and future travel needs will determine our ability to reduce travel and shift away from private vehicles.
- Waste solutions can deliver significant emission reductions across all scenarios and time periods. Notably, they will have a continuing impact even when electricity decarbonisation occurs.

Implications for Greater Sydney

Based on the analysis of the three scenarios, the implications for Greater Sydney are both significant and challenging:

1. **Net zero by 2050 or sooner is achievable** – All scenarios could achieve net zero emissions in 2050 with or without the use of carbon offsets (up to 4MT). However, global warming is due to cumulative emissions over time and hence early and significant action will have the greatest mitigative effect. Achieving net zero emissions earlier than 2050 is more easily achieved through the accelerated future transition scenario – 18MT between 2040 and 2050 versus 40 and 94 MT for the managed future transition and current settings scenarios respectively. The accelerated future transition represents an ambitious scenario of emissions reduction and the potential to achieve net zero emissions earlier than 2050. This is based on an accelerated take up of existing and new zero emission technologies and behaviors in Greater Sydney supported by NSW policies, planning frameworks and programs. Achieving net zero emissions in Greater Sydney and the associated pipeline of policies and investment could yield significant economic and social benefits for Sydney and NSW citizens including more jobs, household savings, health benefits and resilience to the impacts of climate change.

2. **Early action should focus on strategies that drive emission reductions before significant electricity decarbonisation occurs** - Early action that focuses on building efficiency, new building standards and waste reduction and management will be required to achieve short term emission reductions and ensure Greater Sydney plays a leading role in directing the state's trajectory towards net zero emissions from the start. In addition, action should be taken now to future proof our buildings and infrastructure to take advantage of future lower carbon electricity, such as electric vehicles and broader electrification of the economy.

3. **Greater Sydney's three cities will play different roles in delivering emission reductions** - The review of the *Greater Sydney Region Plan* should enable each of Greater Sydney's three cities (Western Parkland, Central River and Eastern Harbour) to play a different role and emphasis in the delivery of emission reductions. This should be particularly considered in the context of transport emissions as, without intervention, transport will soon overtake energy as the largest contributor to Greater Sydney's emissions. Planning frameworks can influence the differing role of centres in these three cities, the nature of land use and employment growth and create policies and infrastructure programs that enable future transport emission reductions.

4. **Local energy generation will play a significant role in Sydney's emissions future.** Rooftop solar PV is expected to contribute up to 25% of total electricity generation in 2050. The Western Parkland City and Central River City have significant potential for rooftop solar PV due to the higher proportion of single dwellings and large roofs across industrial areas. The regulatory framework and programs that support the installation of local solar should continue. In addition, further support for batteries installations (community or household level) should be considered by Government to maximise economic value of the private investment in solar PV.

5. **The emissions offset market should be considered when determining emissions reduction actions within Greater Sydney.** Greater Sydney's activities influence over one third of NSW emissions. The analysis in this report suggest that social and economic opportunities could be maximised through local emission reduction actions, before the need for carbon offsetting to achieve net zero emissions by 2040 or 2050. However, the quantum of greenhouse gas emission offsets required is materially large in the context of the current NSW and/or Australian markets. The market demand for offsetting is also expected to grow into the future. Further analysis would be required inform any potential NSW policy recommendations.

6. **Limiting temperature impacts requires us to think about our carbon budget -** The challenge of moving Greater Sydney towards net zero emissions within a timeframe that supports the world staying within a 1.5-degree change is significant but achievable through immediate action. Limiting temperature increases and related economic and social consequences requires a shift in thinking from achieving net zero emissions at a point in time to monitoring Greater Sydney's total emissions released over time. This type of carbon budget approach is recommended to ensure short term action, such as building efficiency and new building standards, is prioritised and accelerated. While the accelerated decarbonisation scenario achieves net zero emissions by 2050, no scenario reduces emissions within a trajectory that keeps Greater Sydney within its carbon budget without significant offsets, highlighting the need for early action.

A Collaborative Framework for Implementation

The scenarios have been developed in collaboration with stakeholders from various NSW Government agencies including the Department of Planning and Environment (DPE), Transport for NSW (TfNSW) and the Environmental Protection Agency (EPA). Input from these agencies was used to consolidate and calibrate the impact of existing NSW Government policy as well a range of emission reduction scenarios including renewable energy, energy efficiency and the opportunities in the land use, transport and waste sectors. The scenarios outlined in this report should be considered as a snapshot in time, taking into account current policies, technologies and research. The collaborative process used to develop the scenarios outlined in this report provides the Greater Sydney Commission and the NSW Government with a framework for each agency to assess and quantify the role of individual policies, parties, programs and expenditure to achieve emission reductions across Greater Sydney.

Ongoing review, refinement and monitoring of these scenarios through a net zero scenario planning and reporting framework would provide NSW Government with a clearer lens on how Greater Sydney is progressing towards a zero emissions future.

2. UNDERSTANDING GREATER SYDNEY'S EMISSION PROFILE

This report outlines reduction pathways for city-induced emissions across energy, transport and waste, providing just one part of the picture to achieve net zero emissions across NSW.

In 2015, countries around the world signed the Paris Agreement, committing to reduce carbon emissions to a level that keeps global warming to under 1.5° C. Cities account for 70% of global emissions so actions taken by city communities will play a significant role in fulfilling these commitments.

To enable cities and regions to measure, report and take action on greenhouse gas emissions in a consistent way, the World Resources Institute (WRI) and ICLEI Local Governments for Sustainability developed the Global Protocol for Community-scale Greenhouse Gas Emission Inventories (GPC). The GPC provides two approaches to developing community carbon inventories, a "territorial" approach and a "city-induced" (consumption based) approach.

Territorial emissions focus on where the emissions physically occur. Examples of emissions that are calculated under this approach include emissions generated by coal fired power generators, landfill sites and wastewater treatment centres.

However, there is a whole lot of activity in cities that indirectly results in these emissions occurring, like heating and cooling our homes, turning on lights, running hospitals and schools, and generating waste. **City-induced (or consumption based) emissions** assigns the responsibility of emissions to the consumers of products and services rather than the producers.

Neither approach is better or worse than the other. Applying different accounting methods can reveal alternative ways to reduce greenhouse gas emissions. Territorial or production accounting supports supply side strategies such as incentivising suppliers to switch to cleaner fuels or to adopt low emission technologies. City-induced emissions reporting supports demand side and community-based strategies such as measures to reduce energy use, waste generation and travel.

For this reason, and consistent with the 2017 *Exploring Net Zero Emissions for Greater Sydney* report, this report analyses emissions and emission reductions pathways for city-induced emissions from key energy, transport and waste emission sources including:

- Building electricity and gas consumption
- Resident and journey to work travel; and
- Residential, commercial and industrial operational waste.

Emissions data for this work has been sourced from the *Resilient Sydney Platform* which sources data from local utilities and NSW Government agencies including Ausgrid, Endeavour Energy, Jemena, Transport for NSW, ABS and NSW EPA.

Due to data availability, a few key emission sectors not explicitly covered, including transport freight emissions, fugitive emissions and the embodied emissions from building construction. As Greater Sydney grows and develops, emissions associated with embodied emissions and freight in particular would be expected to grow and further analysis needs to be undertaken to account for these additional emissions.

EMISSION SOURCES AND STRATEGIES COVERED IN THIS REPORT

3. BACKGROUND

NSW has committed to achieving net zero emissions by 2050. What is the role of Greater Sydney in delivering this outcome?

National Policy

Under the Paris Agreement, most countries, including Australia, have agreed to limit warming at 1.5°C or "well below" 2°C above pre-industrial levels. More recently, the IPCC SR15 (Special Report 2018), also known as the Global Warming of 1.5 Degree report, released updated emission reduction pathways required to limit global warming to 1.5°C.

NSW Commitment to Net Zero Emissions

In response to our National and global agreements, the NSW Government has committed to achieving a 50% reduction in emissions by 2030 and net zero emissions by 2050[2]. This aspirational objective is intended to provide a clear statement of the government's intent, commitment, level of ambition and to set expectations about future emissions pathways that will help the private sector and government agencies to plan and act.

This objective is supported by *Net Zero Plan Stage 1: 2020–2030*[1] which sets out how the NSW Government will deliver on significant state wide emission reductions over the next decade, including:

- Improve the National Construction Code (NCC) and Building Sustainability Index (BASIX) to future proof new buildings with EV ready infrastructure and provide a pathway to deliver cost-effective, low emissions outcomes for residential, commercial and public buildings.
- Support the uptake of renewable energy, energy efficiency and demand/peak shifting technologies
- Manage organic waste through composting and food/garden waste management infrastructure.
- Lead a strategy to achieve net zero embodied carbon in building materials

The Role of Cities in Climate Action

Cities consume over two-thirds of the world's energy and account for more than 70% of global emissions[3]. If nations are to deliver on their commitments under the Paris Climate Agreement, it is necessary to facilitate large-scale emission reduction in our cities.

In 2016, the *C40 Deadline 2020* report provided an initial roadmap for how cities can respond to meeting the Paris Agreement[4]. The report outlined the pace, scale and prioritisation of action needed as well as the different role and effort required by different types of cities. *Deadline 2020* shows that cities like Greater Sydney with high per capita emissions and GDP have an obligation to reduce emissions steeper and sooner - to share the burden across all cities - based on principles of equality, responsibility and capacity.

In 2017, Kinesis was engaged by the Greater Sydney Commission to analyse potential emission reduction pathways for Greater Sydney, exploring the role of cities including land use, transport and infrastructure planning decisions[5]. The *Exploring Net Zero Emissions for Greater Sydney* report found:

1. Land use, transport and infrastructure planning interventions in Greater Sydney play a significant role in reducing greenhouse gas emissions.
2. Place-based interventions that respond to local land use, infrastructure and transport patterns are required to deliver emission reductions.

This initial report supported the inclusion of emission reduction objectives within the Greater Sydney Region Plan, including key objectives that support the delivery of the state's net zero emissions by 2050 ambition.

Local Government Action across Greater Sydney

Globally, cities and local governments have been taking on climate action with climate change emerging as a key issue in the post-Covid future. To date, 1,990 jurisdictions and local governments cover 1 billion citizens have declared a climate emergency, effectively committing their city to net zero emissions.

In Greater Sydney, the emissions profile varies across local government areas and individual councils have taken different approaches to climate action (Figure 1). In some councils, local, place-based emissions targets have been introduced coupled with local council-area policies. Some examples include:

- **City of Sydney** – the largest contributor to Greater Sydney's emissions has established a target of net zero emissions by 2035, engaging in strategies across key commercial and apartment sectors
- **Blacktown City** – the second largest contributor to Greater Sydney's emissions and with some of the largest growth areas has established a target of net zero operational emissions by 2040.
- **City of Parramatta** – the third largest contributor to Greater Sydney's emissions has established a 60% emission reduction target by 2038, driving emission reductions through planning controls and infrastructure delivery.
- **Northern Beaches Council** – an area of lower development and growth have established interim targets to half community emissions by 2040 and net zero emissions by 2050.
- Smaller Councils like Canada Bay Council, Waverley and Lane Cove Council have established targets of net zero community emissions by 2050 with a focus on collaboration between Councils and with other levels of government.

[2] NSW Government, Net Zero Plan
[3] C40, https://www.c40.org/why_cities
[4] C40, https://www.c40.org/other/deadline_2020
[5] Kinesis (2017) Exploring Net Zero Emissions for Greater Sydney, Greater Sydney Commission

Private Sector Response

There is a growing focus by private sector organisations to increase their transparency and social and environmental responsiveness. This is reflected in several key trends:

- The establishment of the Task Force on Climate-related Financial Disclosure, which now has over 1,900 signatories from the public and private sector companies, including 58% of ASX100 companies.
- Over 40% of the top 100 companies across major countries worldwide report against the UN Sustainable Development Goals
- The Net Zero Asset Managers initiative has grown to 87 investors managing $37 trillion, with the world's three largest asset managers now committing to the net zero goal.

The Purpose of this Report

Interventions that reduce carbon emission by the NSW Government, other levels of government, industry and the community have accelerated in recent times. The awareness and willingness to address climate issues has increased, driven in part to recent events such as severe drought, bushfires and flooding.

This report provides an update to the 2017 *Exploring Net Zero Emissions for Greater Sydney* to reflect current policies and research and provide a range of possible trajectories to demonstrate how Greater Sydney could achieve net zero emissions by 2050 or sooner.

The results of this work are intended to support updated carbon reduction trajectories and interventions within the next version of the *Greater Sydney Region Plan*, and collaborating with NSW Government agencies and local council on driving emission reductions in policies and place-based solutions.

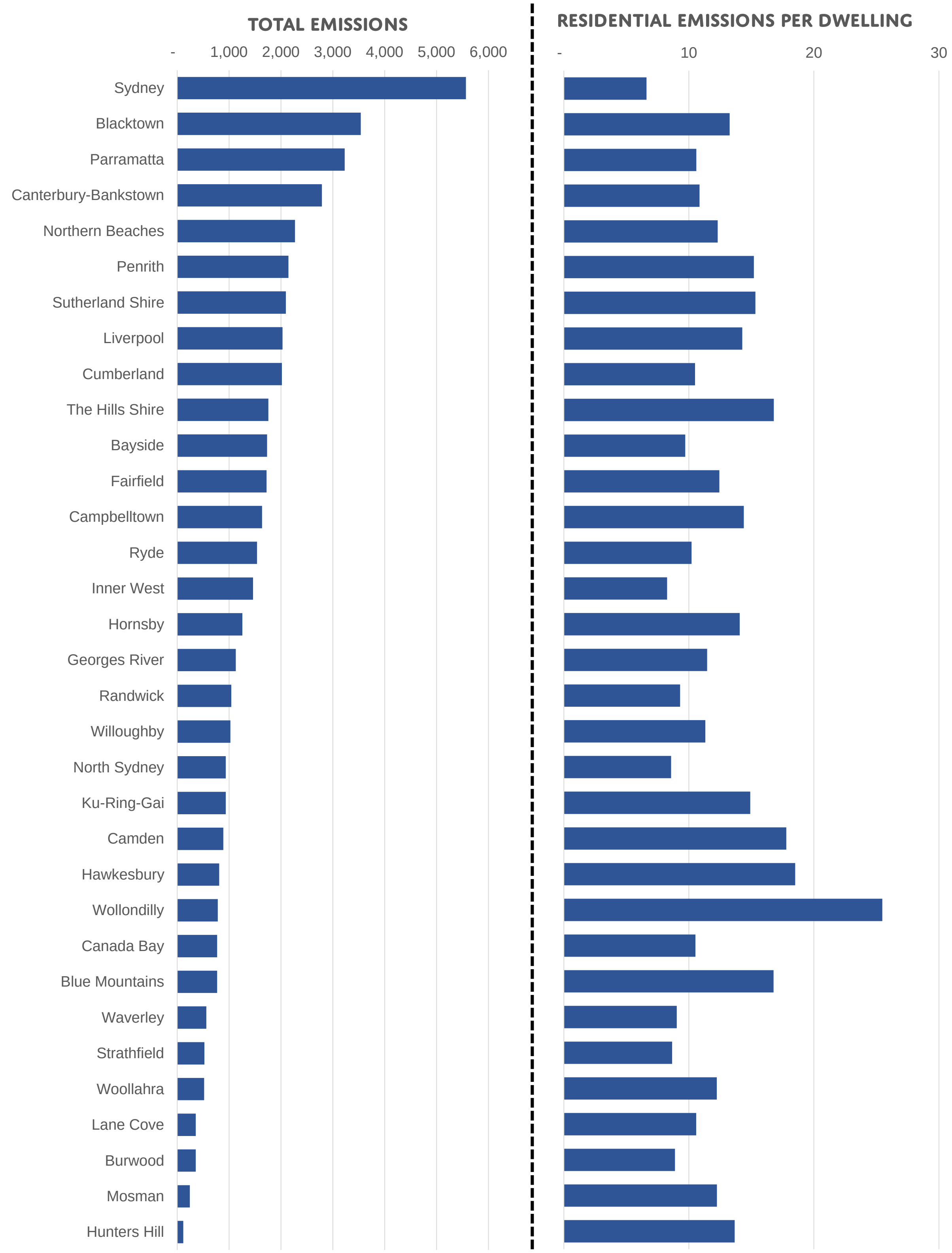


Figure 1: Benchmarking 2018-19 total emissions and residential emissions per dwelling across Greater Sydney LGAs

3. RESPONDING TO A GLOBAL CARBON BUDGET

A **carbon budget** is the total amount of greenhouse gases that can be emitted over time to limit global temperature rise.

In 2018, the International Panel on Climate Change *(IPCC) SR15 (Special Report)*, also known as “Global Warming of 1.5 Degree” report, released updated emission reduction pathways required to limit warming to 1.5°C. This report outlines several key findings for policy makers[6]:

- Limiting global warming requires limiting total cumulative global human-induced emissions since the preindustrial period, that is, staying within a total carbon budget. Globally, the carbon budget is being depleted at a rate of 42 Gt CO2 per year.
- Faster carbon reductions result in higher probability of limiting global heating to 1.5°C. To have a 66% chance of staying below 1.5°C, the report estimates the remaining global carbon budget of 420 GtCO2 (or approximately 10 years of current emissions). To have a 50% chance of staying below 1.5°C, the report estimates approximately 14 years of current emissions.
- Emissions globally will need to be reduced to net zero by 2050 but if the date of reaching net zero emissions is brought forward to 2040 the chance of limiting warming to 1.5˚C is considerably higher.

If the findings of this report are applied to cities or Council areas, this effectively means establishing a carbon budget of approximately 10 years of current (or 2017) emissions and working towards reducing these emissions as quickly as possible to stay within this carbon budget.

The most recent “IPCC SR16 Summary for Policymakers” report released in August 2021 further reinforces the use of carbon budgets by policy makers as the most appropriate mechanism to have the best chance of staying within a global 1.5 degree average temperature rise. The report highlights the need for immediate action that delivers not only net zero emissions by mid-century but drives short term emission reductions to ensure the world stays within a carbon budget. The report also reiterates the findings of previous reports which highlight that the sooner net zero is achieved, the higher the chance of preventing further global heating. Carbon offsets will also be essential to drawdown, offset or remove carbon from the atmosphere.

Our carbon budget is the finite amount of greenhouse gases we can emit to limit global temperature rise to 1.5ºC

Greater Sydney is currently spending its carbon budget at a rate of ~50 MT CO2-e per year. Based on the IPCC Report, it can be estimated that Greater Sydney’s equitable share of emissions expenditure in line with a global carbon budget is:

- For 66% at under 1.5°C – max 10 years of 2016/17 emissions, or 480 MT CO2-e.
- For 50% at under 1.5°C – max 14 years of 2016/17 emissions, or 672 MT CO2-e.

In line with IPCC recommendations, we have applied 10 years of 2016/17 emissions as Greater Sydney’s carbon budget, noting the scope of emissions included in this study excludes transport freight and the embodied emissions associated with construction.

A carbon budget allows Greater Sydney to understand not only a pathway to net zero emissions but the speed at which emission reductions is required in order to contribute to meeting our global warming threshold targets.

Greater Sydney Carbon Budget

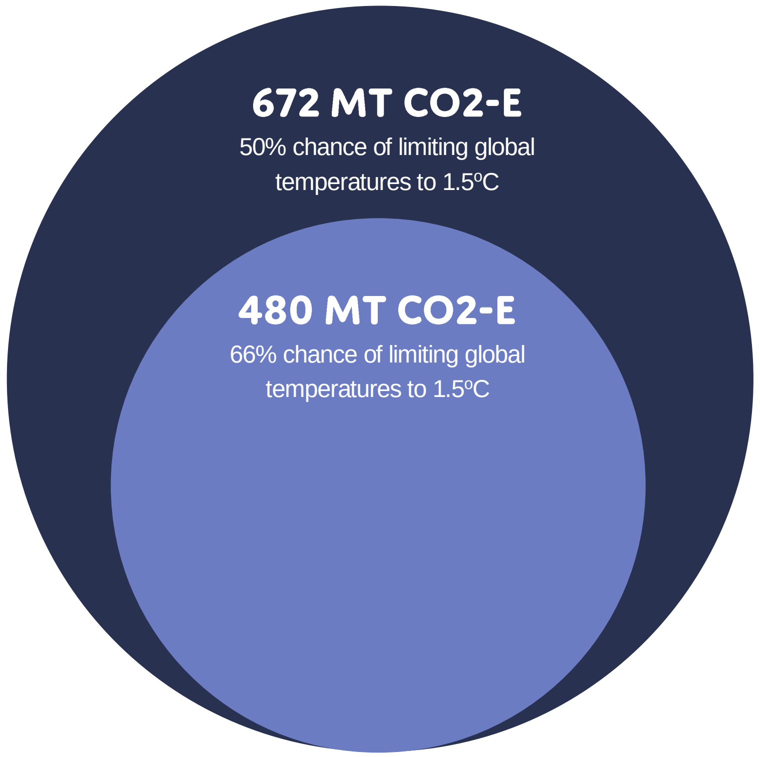


Figure 2: Illustration of Greater Sydney's Carbon Budget

[6] IPCC Special Report (SR) 15 – Global Warming of 1.5 Degrees, https://www.ipcc.ch/sr15/#

4. SCENARIO DEVELOPMENT

To understand the emission reduction potential for Greater Sydney, and the contribution of various policies and strategies, three emission reduction scenarios were explored. The intent of these emission reduction scenarios is to analyse and understand the impact of different policy and program settings that could eventuate across both NSW and Greater Sydney.

All scenarios were developed in collaboration with stakeholders from various NSW Government agencies including NSW Department of Planning, Industry and Environment (DPIE), Transport for NSW (TfNSW) and the NSW Environment Protection Agency (EPA). Input from these groups included both an understanding of current NSW Government policy and programs, as well as expert opinion on additional emission reduction opportunities from renewable energy to building efficiency, transport and waste. The following key NSW Government policies have been reviewed and incorporated into the scenario analysis:

- NSW Net Zero Plan Stage 1: 2020 - 2030 (2020)
- NSW Electricity Strategy (2019)
- NSW Electricity Infrastructure Roadmap (2020)
- NSW Energy Savings Scheme Amendment (2020)
- NSW Peak Demand Scheme (2050)
- NSW Future Transport 2056/ 2061 (Work in progress)
- NSW Electric Vehicle Strategy (2021)
- NSW Waste and Sustainable Materials Strategy (2021)
- National Construction Code updates (draft 2021)

Based on input from stakeholders, the following three scenarios were developed:

1. 2021 Policy Settings

This scenario reflects current NSW and Federal government policy settings as well as conservative technology adoption as referenced from published reports.

2. Managed Future Transition

This scenario extends the current NSW Government policy settings and seeks to deliver a level of decarbonisation that may be reasonably expected based on recent local trends and a moderate level of ambition.

3. Accelerated Future Transition

This scenario represents an ambitious scenario of emissions reduction and the potential to achieve net zero emissions earlier than 2050. This is based on an accelerated take up of existing and new zero emission technologies and behaviors in Greater Sydney supported by NSW policies, planning frameworks and programs.

Interventions included in each scenario are based on existing government policy documents as well as the expansion of these interventions deemed achievable based on state agency expert input, industry research and high-level marginal abatement cost-curve analysis.

Each scenario has a different emphasis, both in terms of the timing of interventions as well as the overall level of intervention. The timing and level of intervention reflects different urban form, planning and infrastructure futures, as well as different cost and benefit implications which play out differently across Greater Sydney's three cities,

Further analysis on the specific costs and benefits associated with each intervention will be required to determine the overall cost and benefit of each scenario. This is discussed further in Chapter 6 of this report.

The Accelerated Future Transition scenario was developed as a pathway that simulated the following:

- **Prioritising and maximising the impact of NSW Government policies**

  Collaboration with NSW state agencies was undertaken to forecast the potential impact current policy positions. For example, teams within DPE were consulted to understand the implications of the NSW Electricity Strategy for electricity decarbonisation. This was further validated with independent research including analysis from AEMO's Integrated System Plan to determine an accelerated electricity decarbonisation scenario that reflects the most ambitious but achievable trajectory.

- **Technology uptake driven by market expectations and accelerated future NSW Policy**

  Economic indicators support an accelerated market uptake of existing and new emission reduction technologies. Short term projections of high electricity prices and decreasing technology costs support an accelerated uptake of building efficiency measures including rooftop renewables coupled with batteries and fuel switching from gas to electric appliances. The NSW Energy Savings Scheme Amendment and Peak Demand Scheme could accelerate this uptake. Additionally, electric vehicles are expected to reach parity with internal combustion vehicles by 2025 to 2030 driving the accelerated uptake of Electric Vehicles (Bloomberg New Energy Finance EV Outlook). The key priorities and actions in the NSW Electric Vehicle Strategy including infrastructure investment and subsidies could be brought forward to drive the uptake in Greater Sydney.

- **Continuing innovation and behavioral change**

  The accelerated decarbonisation scenario also incorporates on-going technology innovation and behavioral change in Greater Sydney residents and businesses that can lead to rapid emission reductions. For example, technology innovation in Mobility-as-a-Service (MaaS) and autonomous vehicles, continuing and expanding work from home patterns, and a planning framework that can support an increased role for local centres can reduce car travel and associated emissions.

A comparison of the three scenarios under 6 key thematics is provided in Table 1, highlighting the key elements of intervention under the themes of:

- Urban form
- Electricity
- Buildings
- Fuel switching
- Transport
- Waste

The impact and role across each of Greater Sydney's three cities is discussed further in the next section of this report. Detailed modelling assumptions used in the scenarios is provided in the **Appendix** to this report.

A Process for a Collaborative Framework

The scenarios outlined in this report should be considered a point in time, understanding current policies, technologies and research.

The collaborative process used to develop the scenarios outlined in this report provides the Greater Sydney Commission and the NSW Government with a framework for each agency to assess the role of individual policies, programs and expenditure on achieving emission reductions across Greater Sydney.

Ongoing review and refinement of these scenarios would provide NSW Government with a clear view on how Greater Sydney is progressing towards a zero emissions future. This is further discussed in Section 7 of this report.

GREATER SYDNEY EMISSION REDUCTION PATHWAY NARRATIVES

THEMATIC	1. 2021 POLICY SETTINGS	2. MANAGED FUTURE TRANSITION	3. ACCELERATED FUTURE TRANSITION
Urban form Role of local centres and the three cities framework	• Employment will be concentrated in metropolitan centres (the Harbour CBD, Greater Parramatta and Bradfield / Western Sydney Aerotropolis) • Urban growth continues with little change to the current split between urban renewal, urban infill and land release.	• Employment grows in metropolitan and strategic centres driving increased worker containment. • Increased density and housing diversity along transport corridors.	• An interconnected metropolis with high worker containment in metropolitan, strategic and local centres. Behavioral changes including increased working from home continues into a post COVID world. • Housing diversity and affordability is prioritised. Interventions to lower housing cost by leveraging connectivity and accessibility are pursued.
Electricity Decarbonisation of electricity	• A minimum expected decarbonisation of electricity based on federal government assumptions and historical projections by AEMO. This transition does not consider the nuances of the NSW Electricity Strategy including the expected activity in renewable energy zones.	• A managed transition influenced electricity transition that incorporates the conservative decarbonisation impact of the NSW Electricity Infrastructure Roadmap, Energy Savings Scheme amendment and Peak demand scheme.	• The electricity transition reflects the lowest emission factors incorporating aggressive decarbonisation forecasts by the Electricity Infrastructure Roadmap, Energy Savings Scheme amendment and Peak demand scheme.
Buildings Efficiency and on-site renewables in existing and new buildings	• Reviews to the BASIX and National Construction Code are limited, reducing the impact of new development controls on the significant growth areas of the Western Parkland and Central River City.	• The COAG Energy Council's Trajectory for Low Energy Buildings Reviews drives a comprehensive review of new building standards with higher targets than Scenario 1.	• Market appetite for net zero emissions in buildings are supported through standards in the National Construction Code and net zero carbon building commitments/ initiatives.
Fuel switching towards clean energy sources	• Relatively slow electricity decarbonisation and modest changes in electricity prices limit fuel switching towards electric vehicles and from gas to electric appliances.	• A short to medium outlook for lower electricity prices drives the uptake of electric vehicles and switching from gas to electric appliances.	• Lower electricity prices as well as supporting policy measures including subsidies and infrastructure provision drives the accelerated uptake of electric vehicles and switching from gas to electric appliances.
Transport Changes in travel patterns & mobility trends	• Current travel patterns continue. Higher car use in the Western Parkland City in particular and the need to commute to distant CBDs challenge mode shift strategies.	• High accessibility suburbs surrounding metropolitan and strategic centres and new investment in public transport infrastructure see a decline in car ownership and use. Residents in these suburbs use public and active transport for their short commutes.	• Car use reductions are seen across Greater Sydney as residents either work in their local centre or from home. Mobility as a service options provide alternatives to traditional car ownership and also lead to reductions in non-essential car trips.
Waste Rethinking waste as a resource	• Achieve the targets established by NSW Waste and Sustainable Materials Strategy to 2030. The efficacy of waste reduction and management strategies plateau beyond 2030.	• Achieve the targets established by NSW Waste and Sustainable Materials Strategy to 2030. Future updates to this strategy and continuous innovation in the waste industry creates impact beyond 2030.	• Go beyond the targets established by NSW Waste and Sustainable Materials Strategy to 2030. Circular economy systems make waste a resource and lead to a zero-waste city.

Table 1: Emission reduction pathways and narratives

5. EMISSION REDUCTION PATHWAY RESULTS

Scenarios highlight a different emphasis and outcome for each sector and different emphasis and role for each of Greater Sydney's three cities.

The 2017 report *Exploring Net Zero Emissions for Greater Sydney* highlighted that Greater Sydney is not uniform and differences in land use, resource consumption and travel patterns mean that interventions are more achievable and effective in some areas than others. The study moved us away from the view that Greater Sydney is a monoculture and highlighted how different parts of Greater Sydney will play different roles in delivering emission reductions across the city.

While the emission reduction pathways scenario analysis was undertaken across Greater Sydney as a whole, the analysis highlights a different emphasis across each sector and each of Greater Sydney's three cities (Figure 3). The different emphasis, level and timing of intervention across each sector and each city is highlighted below. While these results are specific to the scenarios in this report, the findings have implications for broader policy considerations.

ENERGY

Electricity decarbonisation is the most significant intervention across all scenarios

Electricity decarbonisation is the most significant intervention, contributing up to 48% reduction in 2050 across the three scenarios. Not only does it drive the overall emission reduction trajectory of each scenario, but highlights the importance of building efficiency strategies and transport electrification.

Rooftop solar PV is expected to contribute up to 25% of total electricity generation in 2050. The Western Parkland City and Central River City have significant potential for rooftop solar PV due to the higher proportion of single dwellings and large roofs across industrial areas. Already today, Western Sydney has some of the highest take-up of solar PV across the State. In parts of Camden and Campbelltown, more than 25% of dwellings have installed rooftop solar PV (APVI).

Building efficiency strategies are important until decarbonisation of electricity

Under the 2021 Policy Settings scenario, a more conservative electricity decarbonisation setting means that in the short-term to mid-term policies that drive energy efficiency (retrofits and building standards) have a larger impact. Under slower rates of electricity decarbonisation, a focus on energy efficiency will be more important to bring down overall emissions faster.

Growth areas of the Western Parkland and Central River Cities provide opportunities to deliver highly efficient and zero carbon new development, while the Eastern Harbour City, with less growth or change, will emphasise retrofitting existing buildings.

A different emphasis across each city

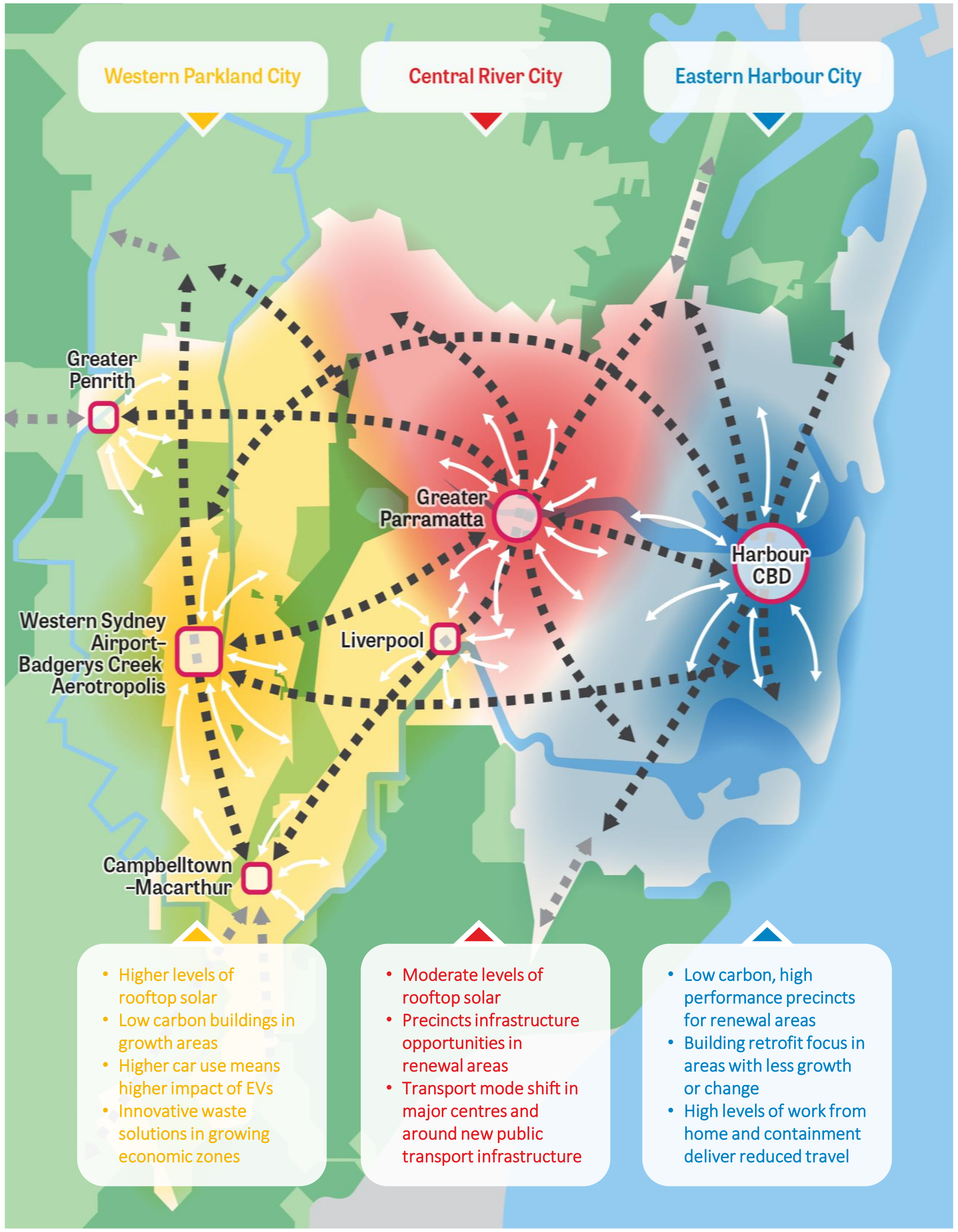


Figure 3: The varying role of the three cities for emission reduction across Greater Sydney

TRANSPORT

Electrification, including EVs, has a larger impact following electricity decarbonisation

Rapid electricity decarbonisation shifts focus to interventions that electrify both the energy and transport sectors. Under the 2021 Policy Settings scenario the impact of electric vehicles and public transport electrification has a much smaller impact until around 2040 when electricity begins to rapidly decarbonise. Conversely, as the number of electric vehicles grows, the impact of vehicle efficiency declines as there are less and less petrol and diesel vehicles on the road.

Higher car ownership and use in the Western Parkland City will see significant benefits and impacts from electric vehicles, while the Central River and Eastern Harbour Cities can leverage significant public transport infrastructure investment to drive mode shift away from private vehicles.

Future travel needs will determine our ability to reduce travel and shift away from private vehicles

The 2021 Policy Settings Scenario assumes a continuation of current urban development patterns with some rebalancing of employment to the Central City and Western City. Under this scenario, significant mode shift away from private vehicles is not expected. The Accelerated Future Transition scenario assumes that a much higher level of worker containment is achieved potentially supported by increased work from home post COVID-19, delivering an 35% reduction in car use, leading to a 3% reduction in emissions by 2050. This reduction is offset by the high expected take up of EV's by 2050 and low emissions electricity. This shift to less travel car use and travel generally is more likely in the Eastern and Central River cities.

WASTE

Waste solutions can deliver significant emission reductions across all scenarios and time periods

Across all scenarios, a suite of waste strategies have a substantial impact across all modelled time periods, cumulatively these account for between 17% and 19% reduction in 2050.
While waste collection services across Greater Sydney provide equal opportunities across all cities, the Western Parkland City with the development of the Aerotropolis provides an opportunity to deliver local solutions to waste management, such as energy to waste, advanced composting and recycling.

OFFSETS

Some level of offsetting will be required in all scenarios

All three scenarios require carbon offsets to either deliver net zero emissions by 2050 or keep Greater Sydney within a carbon budget. The Western Parkland City already plays a significant role already in carbon sequestration through national parks and native vegetation on rural land. The scale of carbon offsetting outlined in the scenarios, however, requires Greater Sydney to look beyond it's geographic boundary. The implications of these offsets are discussed later in this report.

Detailed results for each scenario are outlined in the following pages.

Opportunities for zero carbon new development in the Western Parkland City

Figure 4: Greenfield development in the Western Parkland City

The emissions reduction impact of EVs will grow through decarbonisation of electricity

Figure 5: Electric vehicle charging

Scenario 1 – 2021 Policy Settings

This scenario simulates current policy settings in early 2021, much of which applies to around 2030, and conservative technology adoption as referenced from published reports.
The emission reduction trajectory is presented in Figure 6 outlining the historical emissions from 2005 and projections to 2050. The temporal impact of key strategies is shown in Figure 7. Significant policy interventions include electricity decarbonisation, EV uptake and a suite of waste management policies.

- Electricity decarbonisation models reduced emissions intensity of electricity. This has the greatest overall impact in 2030,2040 and 2050, delivering a 48% reduction on business as usual (BAU) emissions in 2050.
- Retrofits and higher building standards deliver less than a 2% reduction in 2030 and have negligible impact upon emissions in later periods due to electricity emissions intensity reductions. Early action on these strategies is critical for benefits to materialise. These interventions are also considered for their broader secondary benefits beyond emissions reduction that relate to placemaking and increased resilience.
- Electrification grows from negligible impact in 2030 to a 7% reduction in 2050 due to decreased emission intensity of electricity.
- The impact of EV uptake increases rapidly from 2030 to 2050. This is a result of an increased proportion of EV's in Greater Sydney and cross benefits with lower emissions electricity. A reduction of 2% in 2030 increases to nearly 20% in 2050.
- Transport efficiency, which models improved emission intensity of private vehicles has a moderate impact in 2040 but is rendered ineffective by 2050 due to EV take up. EV take up has a greater impact in all years. In later years, these interventions continue to have broader secondary benefits that relate to reduced congestion and improved urban amenity.
- A suite of waste strategies have a substantial impact across all modelled time periods, cumulatively these account for a 17% reduction in 2050.

Based on these assumptions, the following can be determined:

- **Greater Sydney reaches 50% emission reduction by 2030 relative to estimated 2005 baseline.**

  Greater Sydney can play the minimum role in aligning to the 2030 milestone of the NSW net zero trajectory. However, while similar modelling for NSW state-wide emission reduction analysis is needed, it is possible that Greater Sydney will need to deliver greater emission reductions to offset for lower emission reductions across the rest of NSW and maintain the state's trajectory to net zero by 2050.

- **Net zero by 2050 and earlier requires carbon offsets**

  To achieve net zero by 2050, 4 million tonnes of carbon offsets are required in 2050. To achieve net zero by 2040, 13 million tonnes of carbon offsets will be required at 2040. To maintain net zero emissions from 2040, 95 million tonnes of cumulative carbon offsets will be required between 2040 and 2050.

Scenario 1 – 2021 Policy Settings, Emission Reduction Trajectory

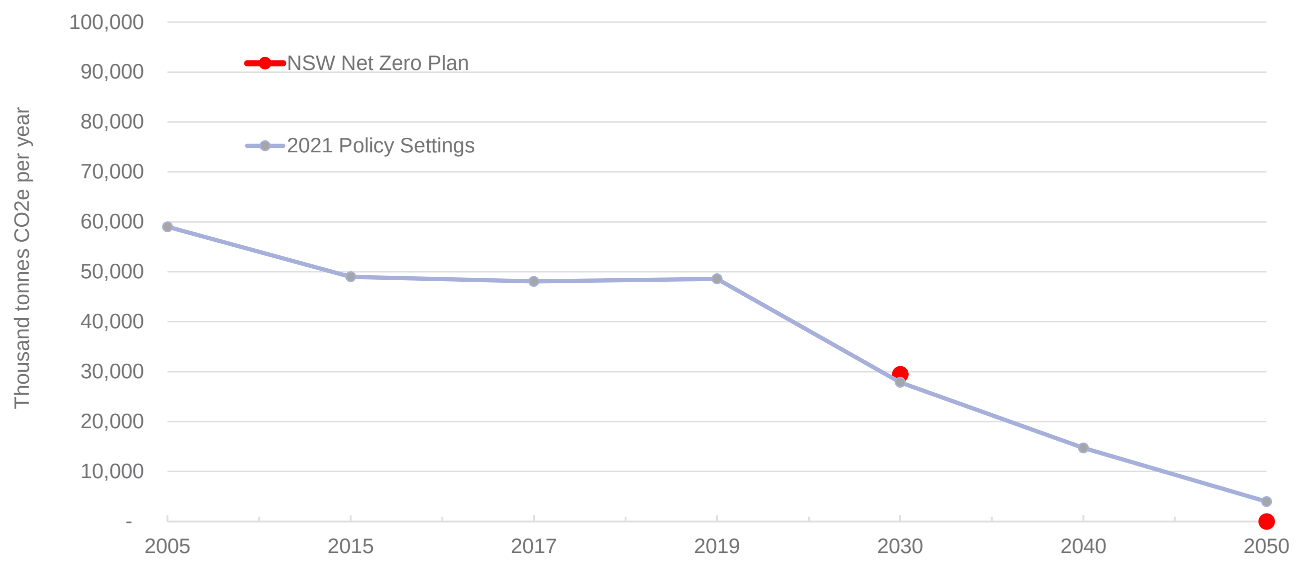


Figure 6: Emission reduction trajectory for 2021 Policy Settings scenario

Scenario 1 – 2021 Policy Settings, Impact of emission reduction strategies

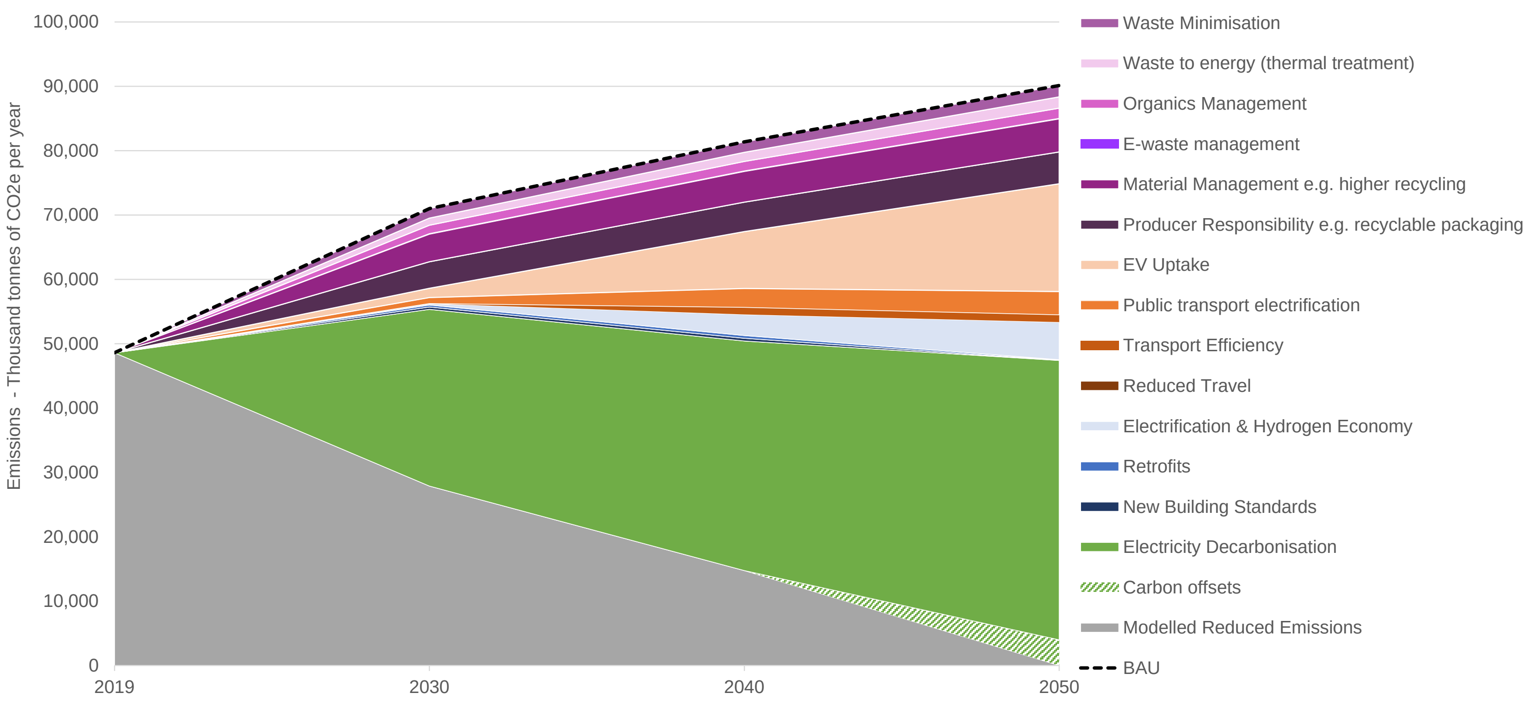


Figure 7: Impact of individual emission reduction strategies for 2021 Policy Settings scenario

Scenario 2 – Managed Future Transition

This scenario extends the current NSW Government policy settings and seeks to deliver a level of decarbonisation that may be reasonably expected based on recent local trends and a moderate level of ambition. These policies are moderately more ambitious than those scene in the current settings. This includes higher diversion rates and increased EV take up. Carbon offsets are used to achieve net zero emissions by 2040. The emission reduction trajectory is presented in Figure 8 outlining the historical emissions from 2005 and projections to 2050.

The temporal impact of key strategies is shown in Figure 9. Significant policy interventions include electricity decarbonisation, EV uptake and a suite of waste management policies.

- The final emission factor remains the same as in the first scenario. This delivers a 48% reduction on BAU emissions in 2050.
- Retrofits and higher building standards deliver a similar reduction in emissions when compared to scenario 1. These interventions are also considered for their broader secondary benefits beyond emissions reduction that relate to placemaking and increased resilience.
- Electrification's impact is higher in 2030 due to an a more rapid decarbonisation of electricity, by 2050 a 7% reduction is realised.
- EV's and electrification are moderately more effective as a result of a more rapidly decarbonised electricity. A reduction of 2% in 2030 increases to nearly 20% in 2050. Electrification of public transport has a greater impact in the Managed Future Transition scenario, a 9% reduction in 2050, due to reduced private car use.
- Transport efficiency, which models improved emission intensity of private vehicles has a moderate impact in 2040 but is rendered ineffective by 2050 due to EV take up. In later years, these interventions continue to have broader secondary benefits that relate to reduced congestion and urban amenity.
- More ambitious strategies reduce emissions further across all modelled time periods, cumulatively these account for a 20% reduction in 2050.

Based on these assumptions, the following can be determined:

- **Greater Sydney reaches 62% emission reduction by 2030 relative to estimated 2005 baseline.** Greater Sydney can play a leading role in delivering the 2030 milestone of the NSW net zero trajectory. However, while similar modelling for NSW state-wide emission reduction analysis is needed, it is possible that Greater Sydney may need to deliver even greater emission reductions to offset for lower emission reductions across the rest of NSW and maintain the state's trajectory to net zero by 2050.

- **Net zero by 2050 and earlier requires carbon offsets**
  To achieve net zero by 2050, no carbon offsets are required in 2050. To achieve net zero by 2040, 8 million tonnes of carbon offsets will be required at 2040. To maintain net zero emissions from 2040, 40 million tonnes of cumulative carbon offsets will be required between 2040 and 2050.

Scenario 2 – Managed Future Transition, Emission Reduction Trajectory

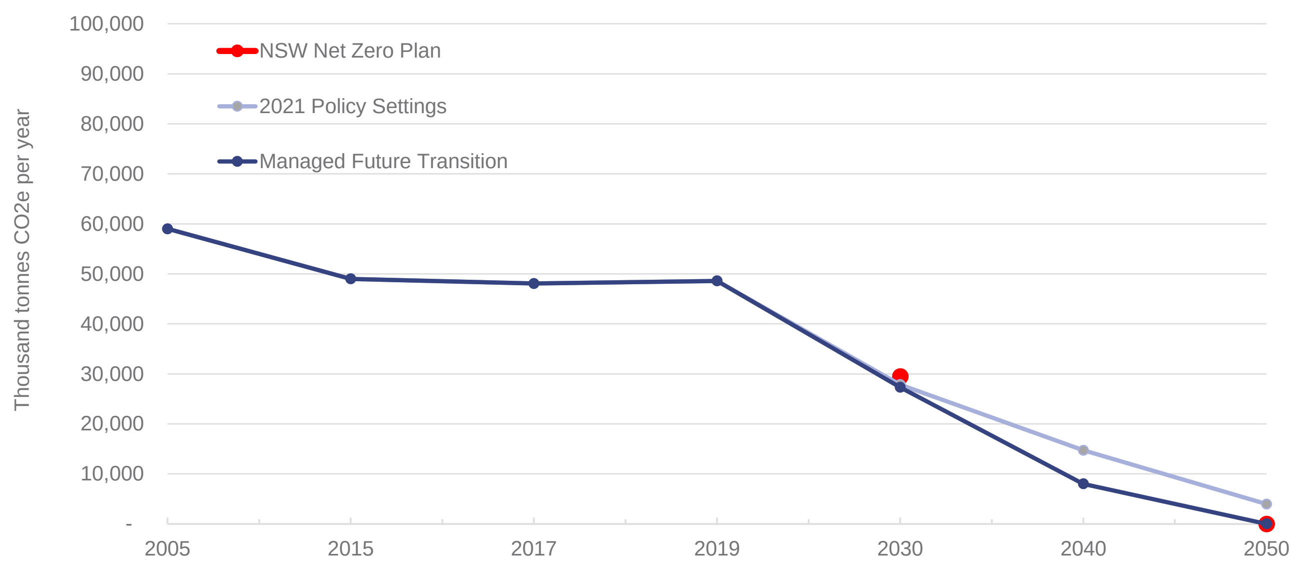


Figure 8: Emission reduction trajectory for Managed Future Transition scenario

Scenario 2 – Managed Future Transition, Impact of emission reduction strategies

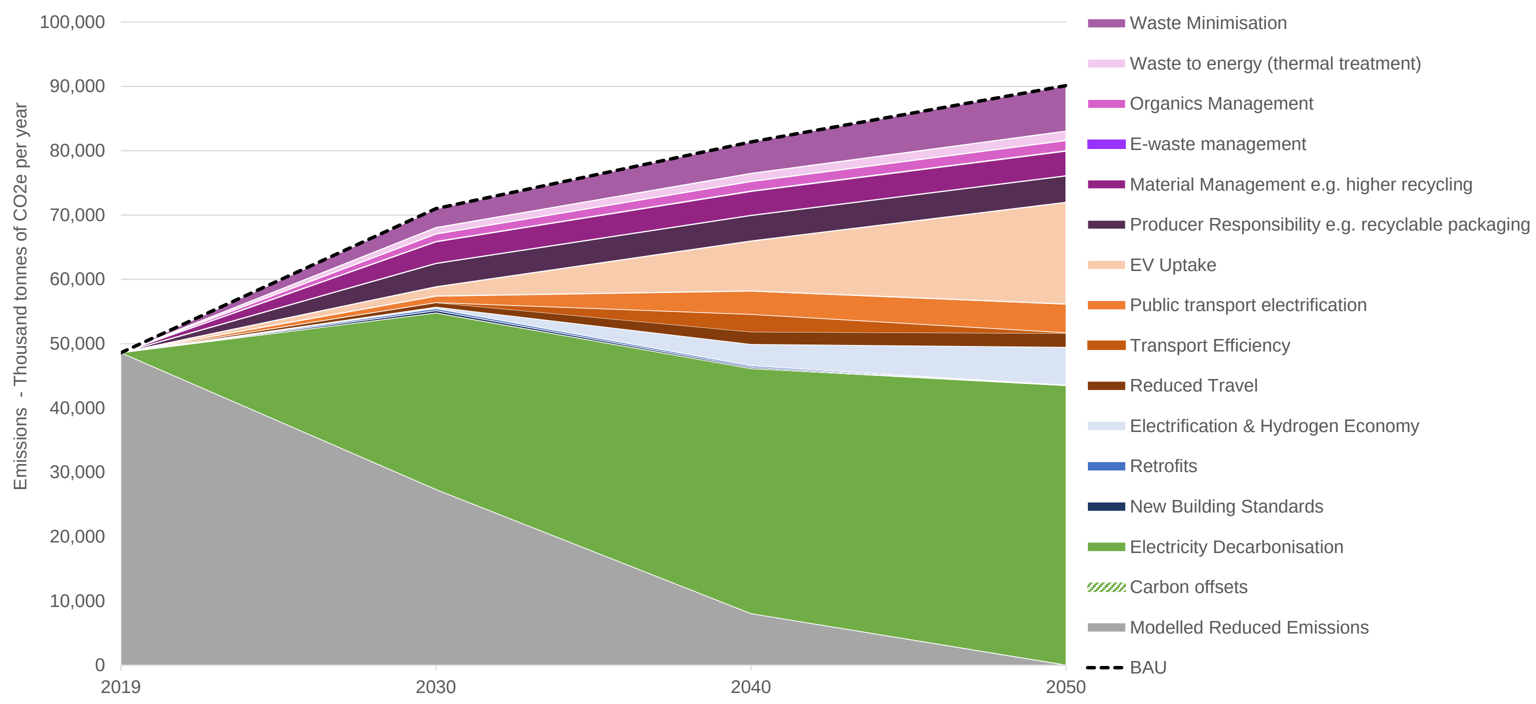


Figure 9: Impact of individual emission reduction strategies for Managed Future Transition scenario

Scenario 3 – Accelerated Future Transition

This scenario represents an ambitious scenario of emissions reduction based on research, stakeholder input and professional opinion. The scenario simulates an accelerated roll out of policy programs driven by NSW Government. These policies have been modelled to represent the greatest possible emission reductions believed to be realistic. The emission reduction trajectory is presented in Figure 10 outlining the historical emissions from 2005 and projections to 2050.

The temporal impact of key strategies is shown in Figure 11. Electricity decarbonisation, mode shift away from car use and ambitious waste reduction and management policies deliver accelerated emissions reduction by 2030 relative to the previous two scenarios. These differences are discussed further below:

- Electricity decarbonises far more rapidly in this scenario. Electricity projected emission factor at 2030 is nearly 60% lower relative to the previous scenarios. This rapid decarbonisation of electricity has a significant impact towards reducing emissions in the short term.
- Retrofits and higher building standards deliver a similar reduction in emissions when compared to scenario 1 and 2. These interventions are most effective prior to 2030. These interventions are also considered for their broader secondary benefits beyond emissions reduction that relate to placemaking and increased resilience.
- The rapid uptake of renewables enhances the impact of building electrification, delivering a 14% reduction in 2050.
- A 35% mode shift from car use to public and active transport as well as overall reductions in car use from continuing work from home practices deliver notable emission reductions. Transport efficiency, which models improved emission intensity of private vehicles also has a notable impact in 2040 but is rendered ineffective by 2050 due to EV take up. In later years, these interventions continue to have broader secondary benefits that relate to reduced congestion and urban amenity.
- EV uptake delivers a reduction of 3% in 2030 increasing to nearly 15% by 2050.
- More aambitious waste strategies including a 30% reduction in waste generation and 65% diversion of organics from landfill have a substantial impact across all modelled time periods, cumulatively these account for a 21% reduction in 2050.

Based on these assumptions, the following can be determined:

- **Greater Sydney reaches 75% emission reduction by 2030 relative to estimated 2005 baseline.** Greater Sydney can play a leading role in delivering the 2030 milestone of the NSW net zero trajectory. By delivering significant emission reductions at 2030, this enables Greater Sydney to offset for lower emission reduction across the rest of NSW and maintain the state's trajectory to net zero by 2050.

- **Net zero reached by 2050 and earlier requires carbon offsets**
  To achieve net zero by 2050, no of carbon offsets are required in 2050. To achieve net zero by 2040, 4 million tonnes of carbon offsets will be required at 2040. To maintain net zero emissions from 2040, 18 million tonnes of cumulative carbon offsets will be required between 2040 and 2050.

Scenario 3 – Accelerated Future Transition, Emission Reduction Trajectory

Figure 10: Emission reduction trajectory for Accelerated Future Transition scenario

Scenario 3 – Accelerated Future Transition, Impact of emission reduction strategies

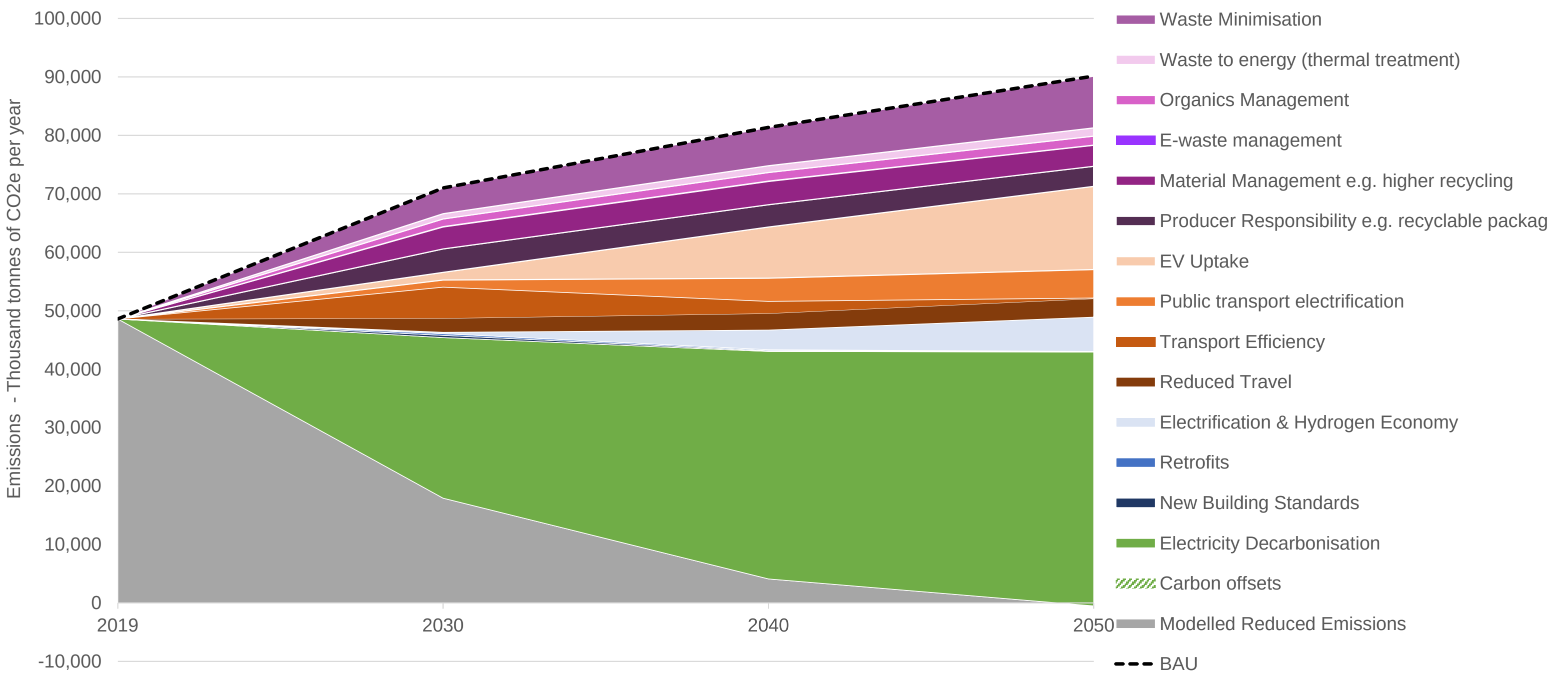


Figure 11: Impact of individual emission reduction strategies for Accelerated Future Transition scenario

Achieving Net Zero Emissions before 2050

All three scenarios outline the implications of achieving net zero emissions across Greater Sydney by 2050. The Accelerated Future Transition scenario provides an opportunity to achieve net zero emissions sooner than 2050 without significant carbon offsets. This scenario will require a combination of:

- Accelerated delivery of NSW Government policies
- Programs to support technology uptake
- Planning frameworks to support an urban form that encourages sustainable behavior
- Carbon offsets

Under the Accelerated Future Transition scenario, achieving net zero emissions by 2040 will require approximately 4 million tonnes of carbon offsets at 2040. The average price for Australian carbon offsets is $20 per tonne as at July 2021. At this price, the cost of achieving net zero emissions from carbon offsets is equivalent to approximately $100 million. These offsets will decrease over time to zero offsets being required at 2050 as various interventions continue to deliver emission reductions.

The cumulative carbon offsets required for Net Zero Emissions by 2040 and continue at net zero emissions until 2050 under each scenario are:

- Current settings: 95 MT
- Managed future transition: 40 MT
- Accelerated future transition: 18 MT

It should be noted, however, that the price of carbon offsets is increasing. The price increased by 21% just between January to July 2021. Market analysts project that the price could more than double in value to $50 per tonne by 2030 (source: RenewEconomy, Reputex). To deliver net zero emissions prior to 2050 will require consideration of a carbon offset procurement strategy that explores risk options to limit exposure to high carbon prices in the future.

The associated cost implications of achieving and maintaining net zero emissions from 2040 at a conservative price of $20 per Australian Carbon Credit Unit (ACCU) are as follows:

- Current settings: $1.9 Billion
- Managed future transition: $0.8 Billion
- Accelerated future transition: $0.4 Billion

Bringing forward the net zero emissions target and associated pipeline of policies and investment can yield significant economic and social benefits for NSW citizens including increased economic activity and employment, household savings, health benefits and increased resilience to the impacts of climate change. This is detailed further in the next section– *Broader Social & Economic Impacts.*

Meeting a Carbon Budget

As discussed previously in this report (and noting the scope of emissions included in this study excludes freight transport and embodied emissions associated with construction), Greater Sydney's carbon budget is approximately 10 years of 2016/17 emissions, or 480 MT CO2-e. All scenarios were analysed to understand their potential to meet this carbon budget.

Under all three scenarios, Greater Sydney exceeds the carbon budget. This occurs in the late 2020's under the 2021 Policy Settings and Managed Future Transition scenarios, and the mid 2030's for the Accelerated Future Transition scenario. It should be noted the IPCC expects the global carbon budget to be exceeded under all modelled scenarios. To remain within the carbon budget, offsets will be required. These offsets represent carbon dioxide removed from the atmosphere and stored in another form. The total offsets required to remain within the carbon budget for each scenario are outlined below.

- 2021 Policy Settings – 343 MT, or 17.15 MT per year from 2030 onwards.
- Managed Future Transition – 250 MT, or 12.5 MT per year from 2030 onwards.
- Accelerated Future Transition – 110 MT, or 6.5 MT per year from 2033 onwards.

Meeting Net-Zero targets by 2050 alone is insufficient to avoid warming of more than 1.5ºC. Carbon dioxide and other greenhouse gasses will continue to accumulate in the atmosphere and contribute to higher average global temperatures until abatement exceeds emissions. For Greater Sydney, remaining within the 480 MT budget will require offsets. Figure 12 demonstrates the benefits of decisive action being taken early, earlier and more ambitious policies lead to a significantly smaller number of offsets being required to remain within the Carbon budget. The Accelerated Future Transition scenario does not exceed the 480 MT budget.

With climate action and limiting global temperature increase is the objective of the modelled policies, it is logical to consider their impact in terms of cumulative emissions. The framework of carbon budgets clearly outlines the urgency of the situation. Early action will ensure that Greater Sydney is contributing fairly to State, National and International efforts to mitigate climate change.

Cumulative emissions and Greater Sydney Carbon Budget

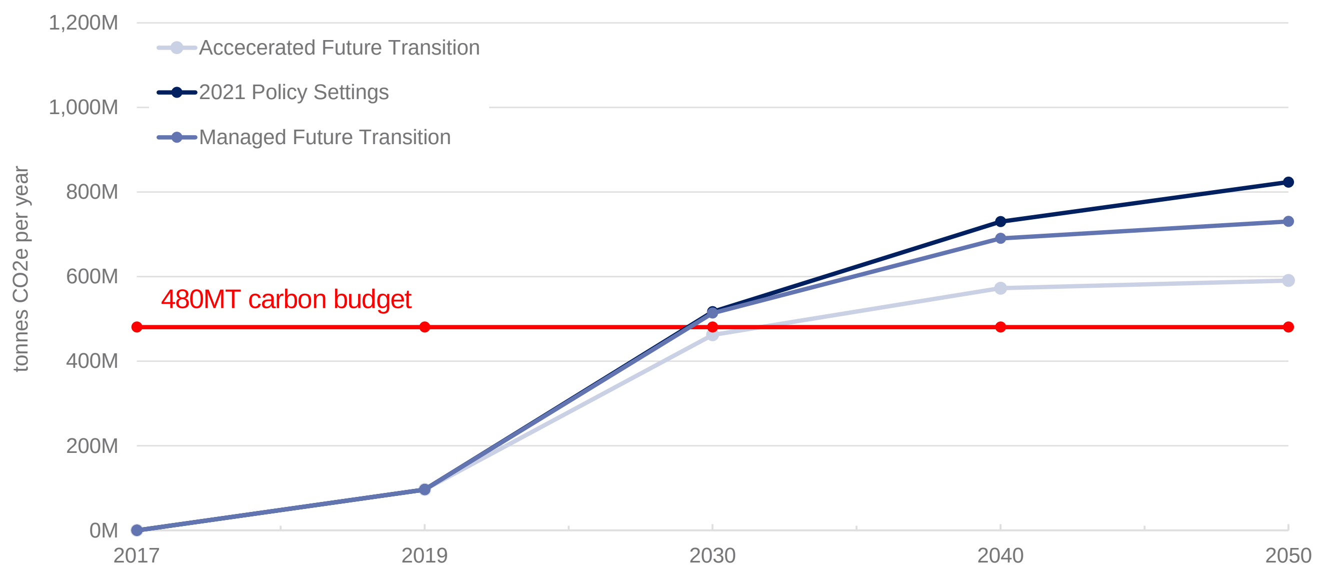


Figure 12: Cumulative emission trajectories of the three modelled scenarios compared against the 480 mt carbon budget and the previously modelled Current Settings scenario

Illustration of Greater Sydney's carbon budget under the three scenarios

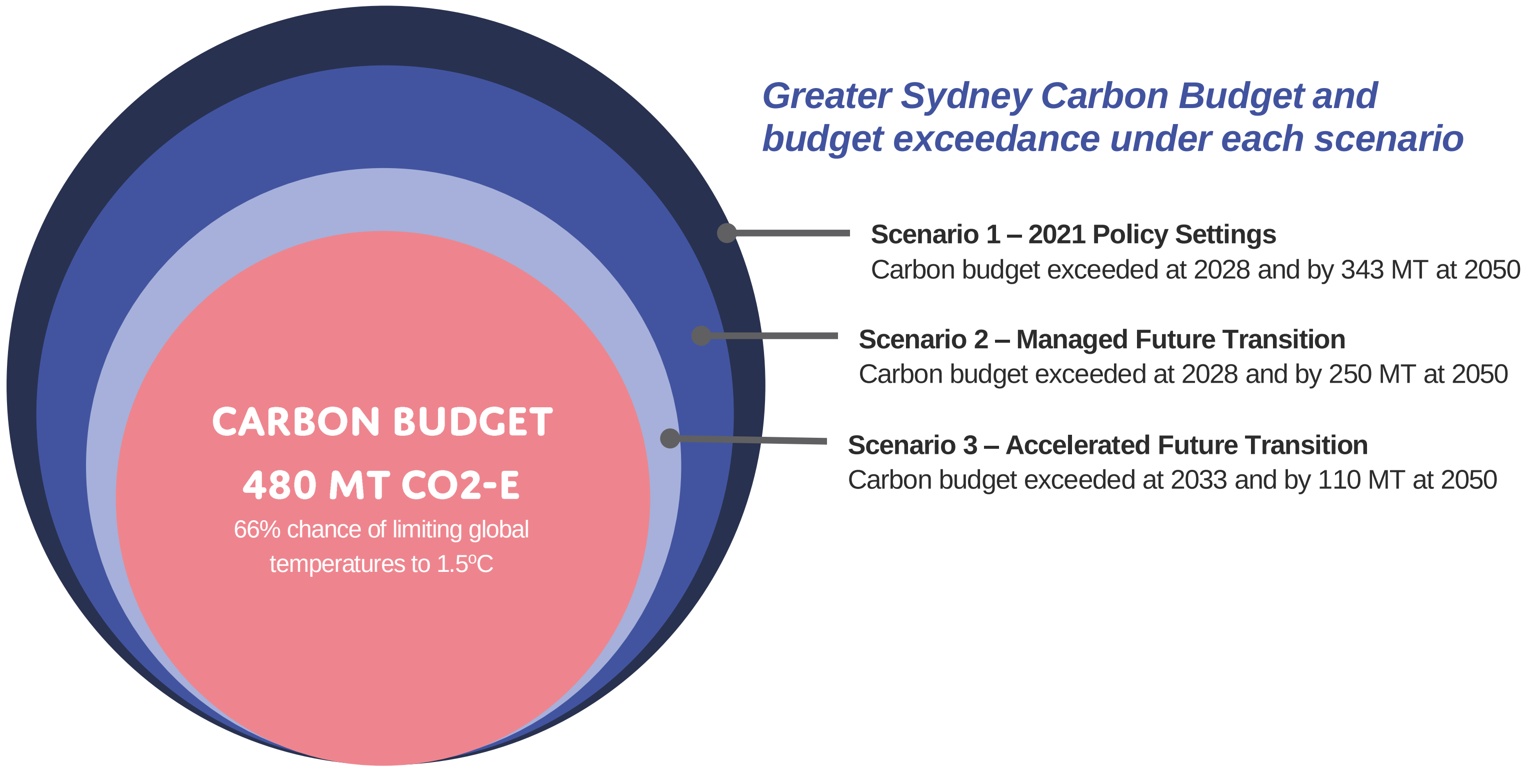


Figure 13: Illustration of Greater Sydney's Carbon Budget under the three scenarios

The Implications of Carbon Offsets

Achieving net zero emissions and meeting a 1.5 degree carbon budget across Greater Sydney, will all require carbon offsets and negative emissions technologies operating at scale.

On top of carbon offsetting solutions such as Power Purchase Agreements (PPAs) or offsite renewable energy, a range of negative emissions technologies are currently under scientific research and evaluation. To date, one of the most practical and cost effective is carbon sequestration via tree planting. This has the additional benefit of providing shade, preventing salinity and soil erosion and providing shelter, food and habitat to native animals. Tree planting is one of the most viable offsetting methods currently, however prolonged drought conditions and the recent Australian bushfires have highlighted the fragility of this method as a long-term reliable solution.

As outlined in the results of the scenario analysis, all three scenarios modelled in this report require carbon offsets to either deliver net zero emissions by 2050 or keep Greater Sydney within a carbon budget. The Australian Carbon Credit Unit market experienced tremendous growth in late 2021 with prices reaching $47 per tonne. Whilst prices have softened somewhat in early 2022 it is likely that the cost of offsetting will increase in the future. To illustrate the cost of offsetting Greater Sydney's emissions we have assumed a highly conservative price of $20 per tonne.

- 2021 Policy Settings – 343 MT, or 21.25 tonnes per year from 2030 onwards.
  Equivalent total cost - $6.8b.

- Managed Future Transition – 250 MT, or 17.5 tonnes per year from 2030 onwards.
  Equivalent total cost - $5b.

- Accelerated Future Transition – 110 MT, or 6.5 tonnes from 2033 onwards.
  Equivalent total cost - $2.2b.

A study by NSW Department of Planning, Industry and Environment (2020) outlines the quantum of carbon offsets available in the agricultural sector across NSW, including carbon offsetting opportunities of retaining and avoiding deforestation, tree planting, soil sequestration and livestock management. This report outlined that between 2020 and 2030 the NSW agricultural sector has cumulative emissions abatement of **approximately 50 MT at 2030**.

The robustness and validity of carbon offsets are increasingly likely to come under scrutiny. There are many examples where overseas offsets have been criticised because of issues ranging from the validity of emissions reductions that resulted in the carbon offset to the broader social and community impacts of supported offset schemes. For example, the validity of some carbon offsets schemes have been questioned due to differing International regulations. It would be logical for NSW to, where possible, target offsets generated within NSW or Australia to support regional investment.

While this report outlines a trajectory of carbon offsets, early investigation into carbon offsetting should be pursued and further understood to determine when carbon offsetting would be required and ensure Greater Sydney's emission reductions and carbon budget is met.

Possible carbon offsetting available from the NSW agricultural sector

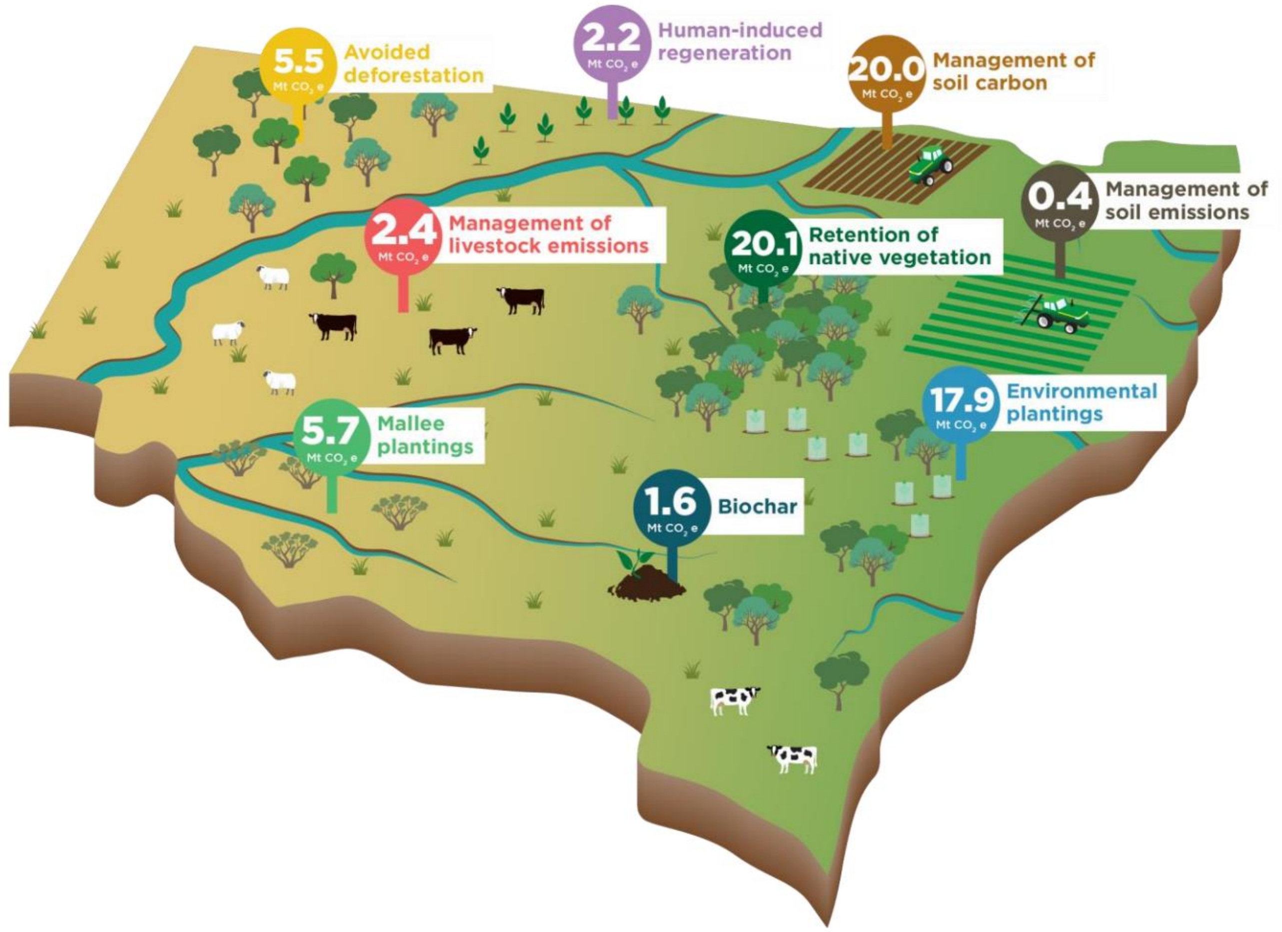


Figure 14: Possible carbon removal opportunities from the NSW agricultural sector
Source: NSW DPIE October 2020

Feasible abatement estimates delivered over 10 years (2020 to 2030) from NSW agriculture. Activities are ranked based on their ability to be integrated into existing agricultural land-use and generate income streams for farmers. For vegetation-based sequestration (natural regeneration, environmental and Mallee plantings, avoided clearing) values are cumulative, estimated from activities commencing 2020 and for biomass only. Additional sequestration in soil carbon from vegetation is not indicated. For emissions reduction activities, the value given is the estimated abatement in the year 2030.

6. BROADER SOCIAL & ECONOMIC IMPACTS

The scenarios analysis in this report incorporate interventions outlined in existing government policy documents (or those currently in development) as well as the expansion of these interventions deemed achievable based on state agency expert input, industry research and high-level marginal abatement cost-curve analysis.

Further analysis on the specific costs and benefits associated with each intervention will be required to determine the overall cost and benefit of each scenario. This chapter provides a qualitative review of the broader social and economic benefits of the interventions outlined in the scenarios, providing a framework for a more detailed cost and benefit analysis.

Climate action delivers opportunities to address social issues of equity and inclusion, and generate economic activity. Recent reports have documented the benefits of climate action globally and conversely the risks of inaction:

- The probable savings (avoided damages) from keeping global warming to a 1.5°C rise, relative to a 2°C rise, are a cumulative US$20-trillion increase in world GDP by the end of the century[7].
- The most vulnerable and poor countries are most at risk from the economic and social impacts of climate change. Developed countries have an obligation to lead the way in climate action. Achieving the 1.5°C target will thus have unequal consequences, with today's poorest countries benefiting the most[5].

The broader social and economic benefits of climate action has been recently highlighted by the C40 Cities Climate Leadership Group through two key reports - "Climate Opportunity: More jobs; Better health; Liveable cities" and "A Green and Just Recovery". Climate action can serve as the way forward for the world's economic recovery from COVID-19. Doing so can have wider social and economic benefits in Cities including:

- Increased household savings
- Job creation
- Health benefits from reduced air pollution
- Reduced road traffic accidents
- Increased productivity through reduced commuting time
- Fuel import savings and increased energy resilience

In addition to emission reductions, the interventions outlined in all three scenarios deliver significant economic and social benefits. While future work may seek to quantity the specific economic and social benefits, Table 2 qualitatively reviews each intervention in terms of their broader economic and social benefits.

This analysis provides a framework to qualitatively understand these impacts as well as providing a framework for further cost-benefit analysis of the specific policies and strategies outlined in this document.

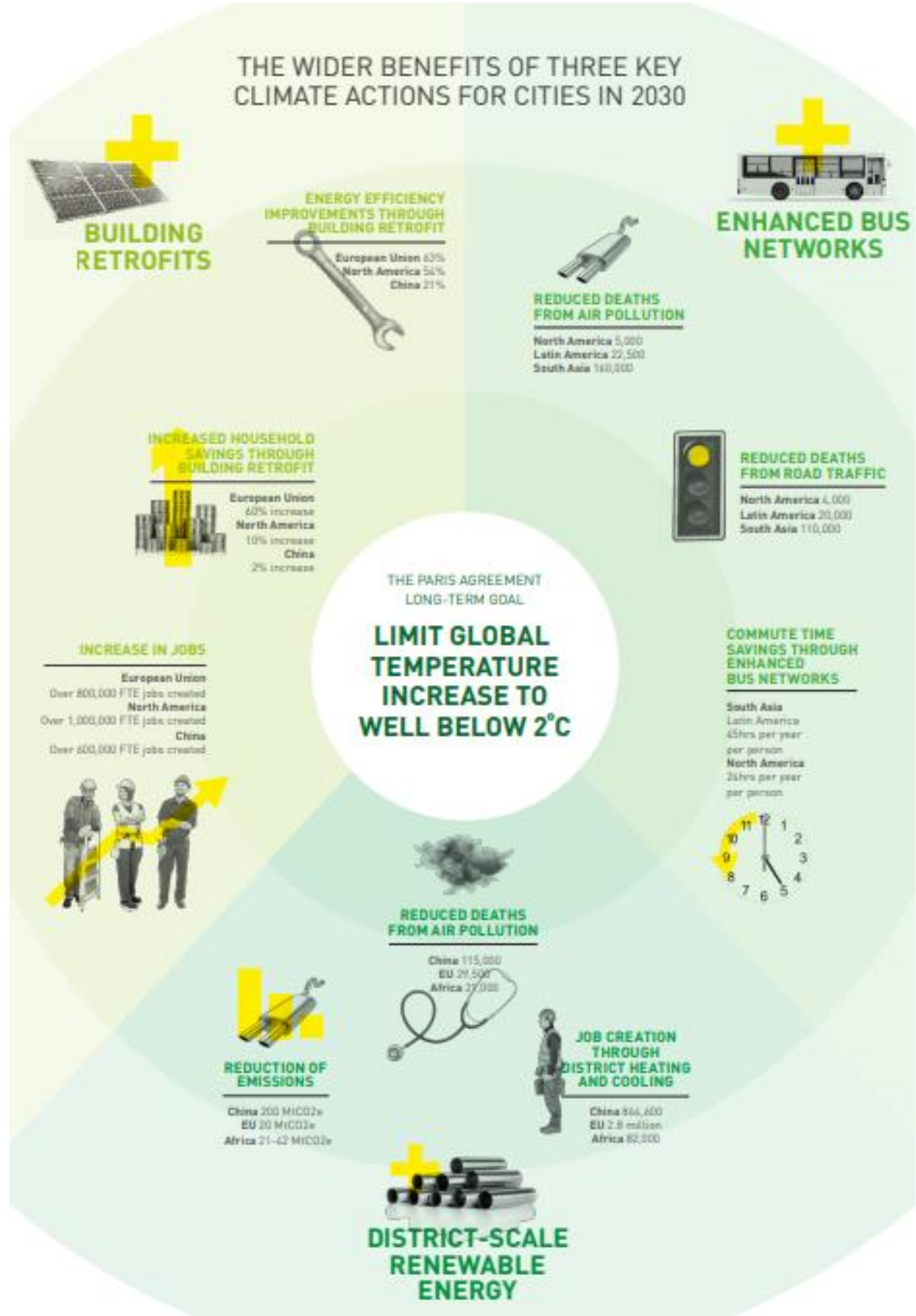


Figure 15: The wider social and economic benefits from climate action for Cities
Source: C40, "Climate Opportunity: More jobs; Better health; Liveable cities".

[7] Marshall Burke, W. Matthew Davis, Noah S. Diffenaugh, 2018 *'Large potential reduction in economic damages under UN mitigation targets'*

SOCIAL AND ECONOMIC IMPACTS OF EMISSION REDUCTION IN GREATER SYDNEY

INTERVENTION	FINANCIAL/ECONOMIC BENEFITS	SOCIAL BENEFITS
Electricity Decarbonisation	• **Jobs Creation -** 44,000 jobs forecasted in the renewable sector by 2025 with ambitious policy. (IRENA Renewable energy and jobs 2020) • **Cost Savings -** Renewables will supply the cheapest power available (projected to be amongst cheapest in OECD), Reduced costs for business in NSW due to low electricity prices will stimulate the economy. (IRENA Renewable Generations costs 2019) • **Cost of Living -** Cheaper energy prices for consumers, IEA 2020 outlook states leading solar schemes now provide the cheapest electricity prices in history/$130 household electricity saving in 2030. • **Regional Infrastructure investment -** Potentially over $32 billion of regional infrastructure investment and associated jobs (NSW Electricity Infrastructure Roadmap). • **Health Costs –** Air pollution costs $1-$8 billion in Sydney (NSW DPE, Health Costs of Air Pollution in Greater Sydney)	• **Health -** Improved air quality and associated health benefits around coal-fired power stations e.g. asthma rates.
New Building Standards	• **Cost savings** - on avoided network investment for water and electricity utilities. Just from BASIX, the estimated benefit of residential new building standards to 2050 is estimated at $294 million to $1.1 billion. (BASIX cost benefit analysis 2009) • **Cost savings** - Reduced energy costs for consumers.	• **Health -** Increased resilience to extreme heat waves, particularly in the Western Parkland Sydney.
Building Retrofits	• **Cost savings** - Reduced energy costs for consumers.	• **Health -** Increased resilience to extreme heat waves, particularly in the Western Parkland Sydney
Building Electrification & Hydrogen	• **Cost savings** - Additional $20 billion of efficiency savings. • **New Markets -** $200 million opportunity per year in the hydrogen industry (NSW Electricity Infrastructure Roadmap) • **Efficiency/Security -** Grid stability via dispatchable power from hydrogen plant. (NSW Electricity Infrastructure Roadmap) • **Cost Savings -** Fuel cell vehicles may save $234 million by 2030 (KPMG, NSW - A Clean Energy Super Power). • **Cost of Living -** Cheaper energy for consumers, electricity from a renewable grid is forecast to be cheaper than gas. • **Health Costs –** Air pollution costs $1-$8 billion in Sydney (NSW DPE, Health Costs of Air Pollution in Greater Sydney)	• **Health -** Reduced particulate matter from gas in homes, better air quality (https://www.osti.gov/biblio/1172959)
Travel Mode Shift	• **Cost Savings -** Reduction to financial costs incurred by congestion across Sydney. • **Jobs Creation -** Increased employment in public transport and mobility as a service. (Infrastructure Australia, Urban Transport Crowding and Congestion) • **Health Costs –** Air pollution costs $1-$8 billion in Sydney (NSW DPE, Health Costs of Air Pollution in Greater Sydney)	• **Health -** Improved public health due to increased active transport. • **Health -** Improved mental health thanks to reduced commuting times • **Quality of Life -** Reduced congestion (Future Transport 2056) • **Health -** Improved air quality (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4049576)
Electric Vehicles	• **Efficiency/Security -** Improved energy security by reduced reliance on fuel imports (C40 Climate Opportunity: More Jobs, Better Health, Liveable Cities) • **Efficiency/Security -** Improved electricity network management and flatter peak demand (if managed efficiently). • **Cost Savings -** Over $1,00 in vehicle costs per year.(NSW Electric Vehicle Strategy) • **Cost of Living -** Future proofing the state against international transition to EV (NRMA-The Future is Electric) • **Health Costs –** Air pollution costs $1-$8 billion in Sydney (NSW DPE, Health Costs of Air Pollution in Greater Sydney)	• **Quality of Life -** Reduced vehicle noise pollution impact on local communities. • **Health -** Improved air quality and associated health benefits. (https://www.carboncounter.com/#!/explore) (https://pubs.acs.org/doi/pdf/10.1021/acs.est.6b00177)

INTERVENTION	FINANCIAL/ECONOMIC BENEFITS	SOCIAL BENEFITS
Vehicle Efficiency	• **Cost Savings -** Reduced fuel costs for consumers and business. (C40 Climate Opportunity: More Jobs, Better Health, Liveable Cities) • **Efficiency/Security -** Improved energy security by reduced reliance on fuel imports (C40 Climate Opportunity: More Jobs, Better Health, Liveable Cities) • **Health Costs –** Air pollution costs $1-$8 billion in Sydney (NSW DPE, Health Costs of Air Pollution in Greater Sydney)	• **Health –** Improved air quality and associated health benefits.
Public Transport Electrification	• **Cost Savings -** Reduced running costs for the public transport fleet. • **New Markets -** Support domestic transition to Electric vehicles, cross benefit of public charging infrastructure available to the public (Future Transport 2056) • **Health Costs –** Air pollution costs $1-$8 billion in Sydney (NSW DPE, Health Costs of Air Pollution in Greater Sydney)	• **Health -** Improved air quality, particularly in centres. • **Health -** Reduced noise pollution on transport corridors • **Amenity –** improved comfort of public transport
Waste Management	• **New Markets** - Opportunity to develop a significant recycling sector • **Jobs Creation** - Industrial/manufacturing jobs • **Cost Savings** - Avoidance of clean-up costs estimated at $167 million in 2015 • **Cost Savings** - Reduced landfill and hence demand for landfill sites. Reference for all benefits: NSW Waste and Sustainable Materials Strategy	• **Quality of Life -** Reduced packaging entering the environment, benefiting our native species. • **Quality of Life -** Improved utility of open space (less waste).
Remaining Emissions (offsets)	• **Regional Investment** – Investment in carbon offsets in farms and bushland areas in regional NSW. On-going innovation in soil charring and other carbon offset mechanisms are likely to increase investment in regional NSW. • **Enhanced biodiversity** – Afforestation is currently the primary carbon offset mechanism. This will enhance biodiversity across NSW. • **New markets –** There could be links to the current NSW biodiversity offset scheme. Effectively growth and development in Greater Sydney can be supported by carbon offsets and biodiversity in regional NSW. Reference for all benefits; Opportunities for prosperity in a decarbonised and resilient NSW	• **Health –** Improved air quality in NSW and associated health benefits • **Quality of Life –** Enhanced biodiversity, benefiting our native species.

Table 2: Economic and Social Benefits of emission reduction in Greater Sydney

7. A COLLABORATIVE FRAMEWORK FOR IMPLEMENTATION

Transitioning to net zero emissions by 2050 or sooner in Greater Sydney requires requires policies and solutions both from the NSW Government and at the local level through council and private sector response.

Key NSW Government interventions will include supporting the decabonisation of electricity, investment in key enabling infrastructure and setting minimum building performance standards through planning policies and controls.

As outlined in the results of this report, how NSW Government interventions plays out at the local level will be varied across Greater Sydney's three cities and local government areas, dependent of the levels and type of growth, land use and built form and local policies such as parking and waste management and collection.

The implementation of emission reductions across Greater Sydney requires significant collaboration at all levels of government. Solutions at the local level will need to be supported by NSW Government policy and investment. And visa-versa, NSW Government policy and investment will need to be supported and implemented at the local level. Some examples include:

- State and federal pricing policies that support EV take-up will require local EV charging infrastructure solutions such as charging outlets in apartment building parking spaces.
- State waste targets require council infrastructure (different bins and waste processing facilities) and supporting education to address separation and contamination.
- Decarbonisation of electricity can be supported through policies which move developments away from gas to all-electric precinct developments
- State investment in public transport infrastructure can be supported by council zoning and parking policies to ensure this investment is maximised to deliver mode shift away from private vehicles.

A role for the Greater Sydney Commission

The Greater Sydney Commission is in a unique position to provide an interface between two key areas of this collaboration across Greater Sydney:

- Understanding policies and infrastructure developed and funded by NSW Government, and
- Understanding land use planning, policies and program delivery by local government.

The process required to analyse and understand the effectiveness of emissions reduction opportunities across Greater Sydney has highlighted the need for both of the above delivery models to be coordinated and mutually reinforcing that emission reduction outcomes are realised at the local level.

It is recommended that net zero pathways for Greater Sydney is supported by an ongoing collaborative framework with both NSW Government and Local Government as follows:

1. Collaboration with NSW Government

The scenarios have been developed in collaboration with stakeholders from various NSW Government agencies including DPE, TfNSW and the EPA. Input from these groups was used to consolidate and calibrate the impact of existing NSW Government policy as well a range of emission reduction scenarios including renewable energy, energy efficiency and the opportunities in the land use, transport and waste sectors.

These scenarios provide a "point in time" analysis, understanding the impact of existing and potential interventions on emission reductions across Greater Sydney. These interventions are in constant change as markets shift, policies are developed and communities respond.

An output of this collaborative process provides the Greater Sydney Commission and the NSW Government with a framework for each agency to assess and quantify the impact of individual policies, programs on achieving emission reductions across Greater Sydney.

It is proposed the collaborative framework be formalized within the Greater Sydney Region and District Plans to implement the following:

1. Annual tracking, forecasting and recalibration on the metropolitan emission reduction impact of NSW Government and local government policies and programs.
2. A whole-of-government approach to recognise and report on the status of the proposed Greater Sydney carbon budget annually.

2. Collaboration with Local Government

The 2017 report *Exploring Net Zero Emissions for Greater Sydney* highlighted that not all areas of Greater Sydney are the same, and that emission reductions interventions at the local level require solutions that respond to place.

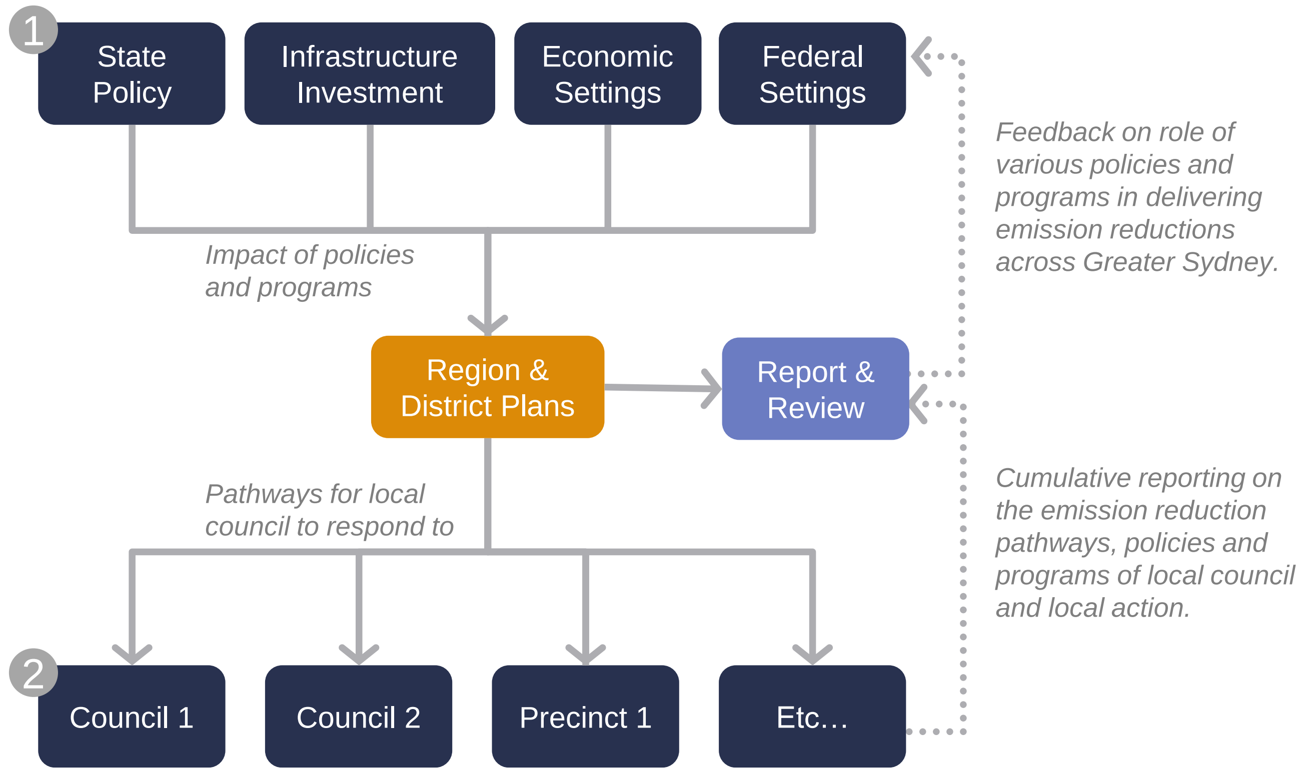
Many of the emission reduction interventions outlined in this report require both validation and implementation by metropolitan councils at a local government and local area scale.

The proposed collaboration with local government includes:

- A net zero scenario planning and reporting framework in partnership with Resilient Sydney so that emissions and emission reduction strategies and policies can be tracked and forecast against local, district and metropolitan boundaries.

The combination of the state and local government collaborations will position the Greater Sydney Commission as the interface and conduit to facilitate, monitor and transparently report on the implementation of emission reductions across Greater Sydney.

A Collaborative Framework for Implementation



APPENDIX

1. Glossary of Terms
2. Specific modelling inputs across all interventions that have been used in the development of the scenarios.

APPENDIX 1: GLOSSARY OF KEY TERMS

BASIX is the Building Sustainability Index, its requirements apply to all residential dwelling types and are part of the development application process in NSW.

Carbon Budget is the predicted volume of carbon dioxide that can be emitted into the atmosphere before certain levels of Global Warming become probable.

Carbon Offset is reduction or Greenhouse gases, numerous systems exist for emitters to purchase offset units.

C40 is a network of global cities committed to addressing climate change.

CO2-e or carbon dioxide equivalent, is the standard unit for measuring greenhouse gas emissions. The unit expresses the impact of each different greenhouse gas in terms of the amount of CO2 that would create the same amount of atmospheric warming.

Global Protocol for Community Scale Greenhouse Gas Emission Inventories (GPC) provides a framework for accounting and reporting citywide greenhouse gas emissions.

Greater Sydney Region Plan is a long term plan for Greater Sydney.

ICLEI – Local Governments for Sustainability is a global network of more than 2500 local and regional governments committed to sustainable urban development. Active in 125+ countries, we influence sustainability policy and drive local action for low emission, nature-based, equitable, resilient and circular development.

IRENA is the International Renewable Energy Agency, it is an intergovernmental agency that promotes the sustainable use of renewable energy.

IPCC the Intergovernmental Panel on Climate Change, the objective of the IPCC is to provide governments at all levels with scientific information that they can use to develop climate policies. IPCC reports are also a key input into international climate change negotiations.

Net-zero emissions means greenhouse gas emissions will be balanced through carbon offsetting and/or sequestration.

Three Cities of Greater Sydney is a vision for the Greater Sydney area where most residents live within 30 minutes of their jobs, education and health facilities, services and great places. This is envisaged to contain the Eastern Harbour City, Central River City and Western Parkland City

APPENDIX 2: MODELLING INPUTS & ASSUMPTIONS

Category	Reduction Category in Charts	Sector	Policy/ technology/ economic considerations	Scenario 1 - Current settings 2030	Scenario 1 - Current settings 2040	Scenario 1 - Current settings 2050	Scenario 2 - Intermediate 2030	Scenario 2 - Intermediate 2040	Scenario 2 - Intermediate 2050	Scenario 3 - Accelerated decarbonisation 2030	Scenario 3 - Accelerated decarbonisation 2040	Scenario 3 - Accelerated decarbonisation 2050	Source
Land Use (dwellings)	Affects Projected Growth in Consumption	Residential	• Dwelling projections aligned to NSW Common Planning Assumptions. • Growth across granular geographies to develop place based understanding and responses	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions). Dwelling typology breakdown to be provided by GSC	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions). Dwelling typology breakdown to be provided by GSC	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions). Dwelling typology breakdown to be provided by GSC	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions). Dwelling typology breakdown to be provided by GSC	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions). Dwelling typology breakdown to be provided by GSC	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions). Dwelling typology breakdown to be provided by GSC	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions). Dwelling typology breakdown to be provided by GSC	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions). Dwelling typology breakdown to be provided by GSC	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions). Dwelling typology breakdown to be provided by GSC	*TfNSW TZP19 Land Use Projection, GSC*
Land Use (jobs)	Affects Projected Growth in Consumption	Non-residential	• Employment projections aligned to NSW Common Planning Assumptions. • Growth across granular geographies to develop place based understanding and responses	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions).	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions).	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions).	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions).	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions).	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions).	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions).	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions).	Total number of dwellings sourced from TfNSW TZP19 Projections (Common Planning Assumptions).	*TfNSW TZP19 Land Use Projection, GSC*
Energy	Electricity Decarbonisation	Residential and non-residential	The electricity grid will transition as coal fired stations reach their end of life and generation from renewable sources increase. The three scenarios represent progressively increasing speeds of the transition. Based on different policy documents and assumptions. • Scenario 1 - NSW DPIE Modelling - Upper Bound. • Scenario 2 - NSW DPIE Modelling - Lower Bound • Scenario 3 - AEMO Hydrogen Superpower.	0.18 at 2030	0.08 at 2040	0 at 2050	0.18 at 2030	0.02 at 2040	0 at 2050	0.18 at 2030	0 at 2040	0 at 2050	*NSW DPIE correspondence* *sub: Greater Sydney Net Zero Emissions - Electricity Factor + EV assumptions* *date: 14/12/2021* *AEMO ISP, NSW DPIE(NSW electricity strategy,Electricity Infrastructure Roadmap, ESS amendment and peak demand scheme implemented), Commonwealth emissions factors*
Energy	Electricity Decarbonisation	Residential and non-residential	The electricity grid will transition as coal fired stations reach their end of life and generation from renewable sources increase. The three scenarios represent progressively increasing speeds of the transition. Based on different policy documents and assumptions. • Scenario 1 - NSW DPIE Modelling - Upper Bound. • Scenario 2 - NSW DPIE Modelling - Lower Bound • Scenario 3 - AEMO Hydrogen Superpower.	*NSW DPIE Modelling-Upper Bound*	*NSW DPIE Modelling-Upper Bound*	*NSW DPIE Modelling-Upper Bound*	*NSW DPIE Modelling-Lower Bound*	*NSW DPIE Modelling-Lower Bound*	*NSW DPIE Modelling-Lower Bound*	*NSW DPIE/AEMO Modelling Hydrogen Super Power*	*NSW DPIE/AEMO Modelling Hydrogen Super Power*	*NSW DPIE/AEMO Modelling Hydrogen Super Power*	*AEMO ISP, NSW DPIE(NSW electricity strategy,Electricity Infrastructure Roadmap, ESS amendment and peak demand scheme implemented), Commonwealth emissions factors*
Energy	Electricity Decarbonisation	Residential and non-residential	Green Energy Markets has developed Projections for distributed energy resources – solar PV and stationary energy battery systems. Distributed renewable energy or on-site solar PV is expected to continue to grow. It is a key priority identified in the NSW Net Zero Plan Stage 1 and contributes to 15-20% of the total electricity generation under AEMO's projections. Take up of rooftop solar PV will be driven by: • Increasing electricity prices. Accompanied by ToU/ smart metering. • Decreasing solar PV prices • Higher new building standards that will require on-site renewables • EV uptake and battery storage will further compliment uptake of renewables. • Changing behavioural patterns including working from home can drive citizens to install solar PV. • On-site renewables are captured as part of the total electricity generation mix and will be differentiated under each scenario based on the transition	Distributed solar: NEM Current installations: 2M+ NEM Current capacity: 10GW+ Slow_growth NEM 2030 installations: 3.5M NEM 2030 capacity: 25GW	Distributed solar: NEM Current installations: 2M+ NEM Current capacity: 10GW+ Slow_growth NEM 2040 installations: 4M NEM 2040 capacity: 30GW	Distributed solar: NEM Current installations: 2M+ NEM Current capacity: 10GW+ Slow_growth NEM 2050 installations: 4.5M NEM 2050 capacity: 35GW	Distributed solar: NEM Current installations: 2M+ NEM Current capacity: 10GW+ Net_Zero NEM 2030 installations: 4M NEM 2030 capacity: 30GW	Distributed solar: NEM Current installations: 2M+ NEM Current capacity: 10GW+ Net_Zero NEM 2040 installations: 5M NEM 2040 capacity: 50GW	Distributed solar: NEM Current installations: 2M+ NEM Current capacity: 10GW+ Net_Zero NEM 2050 installations: 6.5M NEM 2050 capacity: 65GW	Distributed solar: NEM Current installations: 2M+ NEM Current capacity: 10GW+ Export_Superpower NEM 2030 installations: 4.5M NEM 2030 capacity: 40GW	Distributed solar: NEM Current installations: 2M+ NEM Current capacity: 10GW+ Export_Superpower NEM 2040 installations: 6M NEM 2040 capacity: 60GW	Distributed solar: NEM Current installations: 2M+ NEM Current capacity: 10GW+ Export_Superpower NEM 2050 installations: 7.5M+ NEM 2050 capacity: 80GW	*AEMO ISP/ CSIRO Gen Cost/ APVI & UNSW (2017) Spatial Analysis of Solar Potential in Greater Sydney* *Major assumptions is that rooftop silicon-based solar PV accounts for the majority of the uptake and remains the most cost-effective option for installations.*
Energy	New Building Standards	Residential	Beyond the BASIX review in 2022, the National Construction code (NCC) 2022 update is investigating provisions to achieve net zero buildings. This aspiration is supported by GBCA's Net Zero Carbon Buildings Commitment and interest from property companies. The three scenarios provide varying levels of urgency towards net zero buildings. • Scenario 1 - Incorporates expected BASIX review in 2022. As the grid gets greener, less effort is required to achieve net zero buildings and policy stagnates. • Scenario 2 - Scenario 1 + New Energy efficiency standards from COAG Energy Council's Trajectory for Low Energy Buildings and incremental upgrades to the NCC at 2040. Beyond 2040, electricity is near zero emissions. • Scenario 3 - Scenario 1 + Net Zero homes from 2030. Supported by NCC 2022 investigating provisons for net zero buildings, GBCA's Net Zero Carbon Buildings Commitment and developers already delivering zero carbon homes.	at 2022 BASIX target increase as per expected NCC update BASIX +20 for single dwellings BASIX+10 for apartments	As per 2030	As per 2030	at 2022 BASIX +20 for single dwellings BASIX+10 for apartments	Energy Efficiency Standard (20% reduction on elec and gas above higher BASIX for single dwellings; 10% reduction on elec and gas above higher BASIX for single dwellings (BASIX 55 for apts))	As per 2040	at 2022 BASIX +20 for single dwellings BASIX+10 for apartments	Net Zero Emissions buildings	Net Zero Emissions buildings	*Kinesis analysis, BASIX data, COAG (2018): Trajectory for Low Energy Buildings, NCC 2022 and GBCA Net Zero buildings, NSW Net Zero Plan*
Energy	New Building Standards	Non-residential	The National Construction code (NCC) 2022 update is investigating provisions to achieve net zero buildings. This aspiration is supported by GBCA's Net Zero Carbon Buildings Commitment and interest from property companies. The three scenarios provide varying levels of urgency towards net zero buildings. • Scenario 1 - A conservative update of the NCC to include higher sustainability targets for typologies beyond commercial. As the grid gets greener, less effort is required to achieve net zero buildings and policy stagnates. • Scenario 2 - Incremental update of the NCC from COAG Energy Council's Trajectory for Low Energy Buildings • Scenario 3 - Scenario 2 + Net Zero buildings from 2030.	Retain NABERS 5.5 Star from 2020 for commercial 30% reduction in electricity use from 2020 for new health, retail and education 20% reduction in electricity use from 2020 for new industrial 5% reduction in gas use across all non-commercial sectors from 2020	As per 2030	As per 2030	NABERS 6 Star from 2025 for commercial and no gas use. NABERS 6 Star from 2025 for retail centres and no gas use. 60% reduction in electricity use from 2025 for new health and education 40% reduction in electricity use from 2025 for new industrial 15% reduction in gas use across all non-commercial sectors from 2025	As per 2030	As per 2030	NABERS 6 Star from 2025 for commercial and no gas use. NABERS 6 Star from 2025 for retail centres and no gas use. 60% reduction in electricity use from 2025 for new health and education 40% reduction in electricity use from 2025 for new industrial 15% reduction in gas use across all non-commercial sectors from 2025	Net Zero Emissions buildings	Net Zero Emissions buildings	*NABERS, COAG (2018): Trajectory for Low Energy Buildings, NCC 2022 amd GBCA Net Zero Buildings, NSW Net Zero Plan*
Energy	Retrofits	Residential and non-residential	Economic, technological and behavioural changes to increase awareness and appetite for energy efficiency in existing homes. They include: • Increasing electricity and gas prices drive energy efficiency upgrades in existing buildings. Assisted by ToU/ smart metering. • Increasing efficiency of appliances including smart homes and appliances. • General technological improvements in construction materials, passive design guidelines, etc. • Changing behavioural patterns including working from home can drive citizens to apply energy efficiency strategies. • The three scenarios are differentiated by the proportion of existing buildings undertaking refurbishments and retrofits as well as the level of investment or extent of improvements.	10% of existing res buildings have been retrofitted to reduce electricity and gas consumption by ~40% by 2030 10% of existing non-res buildings have been retrofitted to reduce electricity and gas consumption by ~45% by 2030	20% of existing res buildings have been retrofitted to reduce electricity and gas consumption by ~40% by 2040 20% of existing non-res buildings have been retrofitted to reduce electricity and gas consumption by ~45% by 2040	30% of existing res buildings have been retrofitted to reduce electricity and gas consumption by ~40% by 2050 30% of existing non-res buildings have been retrofitted to reduce electricity and gas consumption by ~45% by 2050	25% Existing res buildings have been retrofitted to reduce electricity and gas consumption by ~40% by 2030 25% Existing non-res buildings have been retrofitted to reduce electricity and gas consumption by ~45% by 2030	50% of existing res buildings have been retrofitted to reduce electricity and gas consumption by ~50% by 2040 50% of Existing non-res buildings have been retrofitted to reduce electricity and gas consumption by ~55% by 2040	All Existing res buildings have been retrofitted to reduce electricity and gas consumption by ~60% by 2050 All Existing non-res buildings have been retrofitted to reduce electricity and gas consumption by ~70% by 2050	All Existing res buildings have been retrofitted to reduce electricity and gas consumption by ~40% by 2030 All Existing non-res buildings have been retrofitted to reduce electricity and gas consumption by ~45% by 2030	All Existing res buildings have been retrofitted to reduce electricity and gas consumption by ~50% by 2040 All Existing non-res buildings have been retrofitted to reduce electricity and gas consumption by ~55% by 2040	All Existing res buildings have been retrofitted to reduce electricity and gas consumption by ~60% by 2050 All Existing non-res buildings have been retrofitted to reduce electricity and gas consumption by ~70% by 2050	*ClimateWorks (2014): Low Carbon, High Performance,NSW Net Zero Plan*
Energy	Electrification & Hydrogen Economy	Residential and non-residential	An abundance of clean electricity in the future will decrease demand for gas. • Electricity grid transitioning towards renewable energy • Gas prices projected to remain high. • Cost of installing gas infrastructure to new development. • The three scenarios represent increasingly accelerated levels of switching from gas to electricity in buildings.	Reduction in gas use of 10% for res and 0% for non-res by 2030 with switching to electricity	Reduction in gas use of 25% for res and 10% for non-res by 2040 with switching to electricity	Reduction in gas use of 50% for res and 40% for non-res by 2050 with switching to electricity	Reduction in gas use of 25% for res and 10% for non-res by 2030 with switching to electricity	Reduction in gas use of 58% for res and 20% for non-res by 2040 with switching to electricity	Reduction in gas use of 93% for res and 40% for non-res by 2050 with switching to electricity	Reduction in gas use of 58% for res and 20% for non-res by 2030 with switching to electricity	Reduction in gas use of 93% for res and 40% for non-res by 2040 with switching to electricity	All electric world	*ClimateWorks (2014): Low Carbon, High Performanc, NSW Electricity Infrastructure Roadmap,*
Energy	Electrification & Hydrogen Economy	Residential and non-residential	• Australia's National Hydrogen Strategy to develop hydrogen potential across Australia and position as a major global player by 2030. https://www.industry.gov.au/data-and-publications/australias-national-hydrogen-strategy • NSW Hydrogen Strategy under development but identified as a key priority under the NSW Electricity Infrastructure roadmap. https://energy.nsw.gov.au/sites/default/files/2020-11/NSW%20Electricity%20Infrastructure%20Roadmap%20-%20Industry%20Opportunities%20Report.pdf • MoU between NSW Govt. and Federal Government outlines a hydrogen technology program to support commercialisation of hydrogen technologies in NSW. https://energy.nsw.gov.au/government-and-regulation/electricity-strategy/memorandum-understanding • The three scenarios represent increasingly accelerated levels of hydrogen uptake.	None	10% renewable hydrogen + biogas + synthetic methane used to supplement natural gas from 2035 (current distribution system can handle 10%)	50% renewable hydrogen + biogas + synthetic methane used to supplement natural gas from 2040	10% renewable hydrogen biogas + synthetic methane used to supplement natural gas from 2035 (current distribution system can handle 10%)	50% renewable hydrogen + biogas + synthetic methane used to supplement natural gas from 2040	Hydrogen + biogas + synthetic methane completely replaces natural gas and is produced using grid-sourced electricity (i.e. grid emission factor applies)	50% renewable hydrogen + biogas + synthetic methane used to supplement natural gas from 2030	Hydrogen + biogas + synthetic methane completely replaces natural gas and is produced using grid-sourced electricity (i.e. grid emission factor applies)	Hydrogen + biogas + synthetic methane completely replaces natural gas and is produced using grid-sourced electricity (i.e. grid emission factor applies)	*NSW Electricity Infrastructure Roadmap, StrategyFinkel Review, ITP Thermal (2018) Comparison of dispatchable renewable electricity options, COAG National Hydrogen Strategy Workplan (2018)*

Category	Reduction Category in Charts	Sector	Policy/ technology/ economic considerations	Scenario 1 - Current settings This scenario reflects current state government policy settings (including those currently in development) as well as conservative technology adoption as referenced from published reports.			Scenario 2 - Intermediate This scenario extends the current state government policy settings and seeks to deliver a level of decarbonisation consistent with the IPCC SR15 advice for policy makers (effectively Greater Sydney will do its fair share to limit global warming to 1.5 degrees Celsius).			Scenario 3 - Accelerated decarbonisation This scenario represents a best-case scenario of emissions reduction based on an accelerated roll out of current state government policy, as well as additional opportunities based on research, stakeholder input and professional opinion.			Source
				2030	2040	2050	2030	2040	2050	2030	2040	2050	
Transport	Reduced Travel	Residential and non-residential	Private vehicle use expected to reduce from: • Increased employment and worker containment with local centres. • Behavioural changes as citizens continue to work from home. • An interconnected metropolis with improved urban infrastructure, accessibility and mobility options that provide alternatives to private vehicle use. • Any emissions from private vehicle use in the future will also depend on EV uptake and the transition of the electricity grid. Scenario 1 - no reduction in car use Scenarios 2 - reductions based on lower bounds of historical car use VKT reductions between 2013 to 2019. All reduction in car use will result in mode shift towards public and active transport. Scenario 3 - reductions based on mid to upper bounds of historical car use VKT reductions between 2013 to 2019. Incorporates an absolute reduction in travel. That is, some of this private vehicle use reduction will not reflect as increases in public and active	No reduction in per person car use	No reduction in per person car use	No reduction in per person car use	10% reduction in per person car use (private vehicle VKT)	25% reduction in per person car use (private vehicle VKT)	Kept constant from 2040 as unknown and emissions from transport largely determined by electrification and emissions intensity of grid at this stage.	35% reduction in per person car use (private vehicle VKT)	Kept constant from 2030 as unknown and emissions from transport largely determined by electrification and emissions intensity of grid at this stage.	Kept constant from 2050 as unknown and emissions from transport largely determined by electrification and emissions intensity of grid at this stage.	*Assumptions based on historical car use across suburbs in Greater Sydney obtained from the resilient sydney dashboard. The resilient sydney dashboard uses the household travel survey data disaggregated down to a suburb level.*
Transport	Reduced Travel	Residential and non-residential	Private vehicle use expected to reduce from: • Increased employment and worker containment with local centres. • Behavioural changes as citizens continue to work from home. • An interconnected metropolis with improved urban infrastructure, accessibility and mobility options that provide alternatives to private vehicle use. • Any emissions from private vehicle use in the future will also depend on EV uptake and the transition of the electricity grid. Scenario 1 - no reduction in car use Scenarios 2 - reductions based on lower bounds of historical car use VKT reductions between 2013 to 2019. All reduction in car use will result in mode shift towards public and active transport. Scenario 3 - reductions based on mid to upper bounds of historical car use VKT reductions between 2013 to 2019. Incorporates an absolute reduction in travel. That is, some of this private vehicle use reduction will not reflect as increases in public and active	No reduction in car use and no mode shift	No reduction in car use and no mode shift	No reduction in car use and no mode shift	Private vehicle VKT reduction (above) redistributed to public transport based on split detailed in Sources.	Private vehicle VKT reduction (above) redistributed to public transport based on split detailed in Sources.	Private vehicle VKT reduction (above) redistributed to public transport based on split detailed in Sources.	80% of Private vehicle VKT reduction (above) redistributed to public and active transport based on split detailed in Sources. Remainder 20% is an absolute reduction in travel.	80% of Private vehicle VKT reduction (above) redistributed to public and active transport based on split detailed in Sources. Remainder 20% is an absolute reduction in travel.	80% of Private vehicle VKT reduction (above) redistributed to public and active transport based on split detailed in Sources. Remainder 20% is an absolute reduction in travel.	*Mode splits based on 18/19 VKT data across Greater Sydney Res split: Train 5%, Bus 13%, Car as passenger 7%, Ferry, bicycle, motorbike, scooter, other mode, walked only 25% Non-res split: Car as passenger 48%, Train 30%, Bicycle 12%, Walked only 4%, walk linked 3%, Other mode 3%*
Transport	Transport Electrification & Efficiency	Residential and non-residential	The federal government explored Light vehicle emissions standards in 2014. However, these have not yet been implemented. Electric vehicle uptake and the transition of the electricity grid will also effect the roll out of this policy. The three scenarios represent varying levels of ambition and pace of the light vehicle emissions standards policy implementation.	Vehicle fuel efficiency standards reduce emissions to 0.217 kgCO2-e/km for car as driver at 2030	Vehicle fuel efficiency standards reduce emissions to 0.129 kgCO2-e/km for car as driver at 2040	Same as previous. Vehicle efficiency stagnates as EV takeup increases	Vehicle fuel efficiency standards reduce emissions to 0.105 kgCO2-e/km for car as driver from 2030 (assuming light vehicle standards are implemented)	Same as previous. Vehicle efficiency stagnates as EV takeup increases	Same as previous. Vehicle efficiency stagnates as EV takeup increases	Vehicle fuel efficiency standards reduce emissions to 0.105 kgCO2-e/km for car as driver from 2025 (assuming light vehicle standards are implemented)	Same as previous. Vehicle efficiency stagnates as EV takeup increases	Same as previous. Vehicle efficiency stagnates as EV takeup increases	*Climate Change Authority (2014) Light Vehicle Emissions Standards for Australia NSW DPIE, correspondence*
Transport	Transport Electrification & Efficiency	Residential and non-residential	Mobility as a service options including car share and autonomous vehicles in the future provide alternatives to traditional forms of car ownership and use. The impact of these mobility options have been incorporated in the form of reductions in private vehicle ownership and use as well as the uptake of private electric vehicles in the future.	Accounted for within private vehicle use and EV uptake (weaker uptake)	Accounted for within private vehicle use and EV uptake (weaker uptake)	Accounted for within private vehicle use and EV uptake (weaker uptake)	Accounted for within private vehicle use and EV uptake (weaker uptake)	Accounted for within private vehicle use and EV uptake (weaker uptake)	Accounted for within private vehicle use and EV uptake (weaker uptake)	Accounted for within private vehicle use and EV uptake (weaker uptake)	Accounted for within private vehicle use and EV uptake (weaker uptake)	Accounted for within private vehicle use and EV uptake (weaker uptake)	*Kinesis Analysis of MaaS trends*
Transport	Transport Electrification & Efficiency	Residential and non-residential	Public transport becomes more efficient, electrified or switches to hydrogen as the grid becomes greener (see Electricity Decarbonisation)	Public transport becomes more efficient, electrified or switches to hydrogen as the grid becomes greener (see Electricity Decarbonisation)	Public transport becomes more efficient, electrified or switches to hydrogen as the grid becomes greener (see Electricity Decarbonisation)	Public transport becomes more efficient, electrified or switches to hydrogen as the grid becomes greener (see Electricity Decarbonisation)	Public transport becomes more efficient, electrified or switches to hydrogen as the grid becomes greener (see Electricity Decarbonisation)	Public transport becomes more efficient, electrified or switches to hydrogen as the grid becomes greener (see Electricity Decarbonisation)	Public transport becomes more efficient, electrified or switches to hydrogen as the grid becomes greener (see Electricity Decarbonisation)	Public transport becomes more efficient, electrified or switches to hydrogen as the grid becomes greener (see Electricity Decarbonisation)	Public transport becomes more efficient, electrified or switches to hydrogen as the grid becomes greener (see Electricity Decarbonisation)	Public transport becomes more efficient, electrified or switches to hydrogen as the grid becomes greener (see Electricity Decarbonisation)	*Finkel Review, AEMO ISP*
Transport	Transport Electrification & Efficiency	Residential and non-residential	The NSW Electric Vehicle Strategy outlines commitments to increasing the uptake of electric vehicles. It intends to increase EV sales to 52% by 2030–31. That is % of new vehicles that are Evs in 2030-31 can be 52%. This will help NSW achieve net-zero emissions by 2050. The uptake assumptions to the right is across all vehicles (old and new with churn rates applied based on license registrations of old nad new vehicles) in NSW.	11% of fleet at 2030	55% of fleet at 2040	88% of fleet at 2040	12% of fleet at 2030	55% of fleet at 2040	99% of fleet at 2050	19% of fleet at 2030	73% of fleet at 2040	99% of fleet at 2050	*AEMO ISP 2021, NSW DPIE correspondence sub: Greater Sydney Net Zero Emissions - Electricity Factor + EV assumptions*
Transport	Transport Electrification & Efficiency	Residential and non-residential	The NSW Electric Vehicle Strategy outlines commitments to increasing the uptake of electric vehicles. It intends to increase EV sales to 52% by 2030–31. That is % of new vehicles that are Evs in 2030-31 can be 52%. This will help NSW achieve net-zero emissions by 2050. The uptake assumptions to the right is across all vehicles (old and new with churn rates applied based on license registrations of old nad new vehicles) in NSW.	AEMO ISP 2021 Net Zero by 2050	AEMO ISP 2021 Net Zero by 2050	AEMO ISP 2021 Net Zero by 2050	AEMO ISP 2021 Step Change	AEMO ISP 2021 Step Change	AEMO ISP 2021 Step Change	AEMO ISP 2021 Strong Electrification	AEMO ISP 2021 Strong Electrification	AEMO ISP 2021 Strong Electrification	

Category				2030	2040	2050	2030	2040	2050	2030	2040	2050	Source
Waste	Waste Reduction	Residential and commercial and industrial waste	NSW Waste & Sustainable Materials Strategy targets include: • reduce total waste generated by 10% per person by 2030 • have an 80% average recovery rate from all waste streams by 2030 • significantly increase the use of recycled content by governments and industry • phase out problematic and unnecessary plastics by 2025 • halve the amount of organic waste sent to landfill by 2030 The Australian Packaging Covenant Organisation has established the following 2025 targets for packaging: • 100% of packaging being reusable, recyclable or compostable by 2025 • 70% of plastic packaging being recycled or composted by 2025 • 50% of average recycled content included in packaging by 2025 • The phase out of problematic and unnecessary single-use plastic packaging by 2025.	80% of packaging is recyclable by 2030	80% of packaging is recyclable by 2040	80% of packaging is recyclable by 2050	80% of packaging is recyclable by 2030	90% of packaging is recyclable by 2040	100% of packaging is recyclable by 2050	100% of packaging is recyclable by 2030	100% of packaging is recyclable by 2040	100% of packaging is recyclable by 2050	*NSW Waste and Sustainable Materials Strategy APC SSROC Waste Audit for components of waste EPA (2019) Disposal-based audit on Commercial and Industrial waste stream in the regulated areas of NSW APCO Waste Targets for 2025*
Waste	Waste Reduction	Residential and commercial and industrial waste	NSW Waste & Sustainable Materials Strategy targets include: • reduce total waste generated by 10% per person by 2030 • have an 80% average recovery rate from all waste streams by 2030 • significantly increase the use of recycled content by governments and industry • phase out problematic and unnecessary plastics by 2025 • halve the amount of organic waste sent to landfill by 2030 The Australian Packaging Covenant Organisation has established the following 2025 targets for packaging: • 100% of packaging being reusable, recyclable or compostable by 2025 • 70% of plastic packaging being recycled or composted by 2025 • 50% of average recycled content included in packaging by 2025 • The phase out of problematic and unnecessary single-use plastic packaging by 2025.	10% reduction in waste generation per dwelling/job (relative to BAU) by 2030	10% reduction in waste generation per dwelling/job (relative to BAU) by 2040	10% reduction in waste generation per dwelling/job (relative to BAU) by 2050	20% reduction in waste generation per dwelling/job (relative to BAU) by 2030	30% reduction in waste generation per dwelling/job (relative to BAU) by 2040	40% reduction in waste generation per dwelling/job (relative to BAU) by 2050	30% reduction in waste generation per dwelling/job (relative to BAU) by 2030	40% reduction in waste generation per dwelling/job (relative to BAU) by 2040	50% reduction in waste generation per dwelling/job (relative to BAU) by 2050	*NSW Waste and Sustainable Materials Strategy APC SSROC Waste Audit for components of waste EPA (2019) Disposal-based audit on Commercial and Industrial waste stream in the regulated areas of NSW APCO Waste Targets for 2025*
Waste	Waste Management	Residential and commercial and industrial waste	NSW Waste & Sustainable Materials Strategy targets include: • reduce total waste generated by 10% per person by 2030 • have an 80% average recovery rate from all waste streams by 2030 • significantly increase the use of recycled content by governments and industry • phase out problematic and unnecessary plastics by 2025 • halve the amount of organic waste sent to landfill by 2030 The Australian Packaging Covenant Organisation has established the following 2025 targets for packaging: • 100% of packaging being reusable, recyclable or compostable by 2025 • 70% of plastic packaging being recycled or composted by 2025 • 50% of average recycled content included in packaging by 2025 • The phase out of problematic and unnecessary single-use plastic packaging by 2025.	80% of recyclable material is recycled by 2030	80% of recyclable material is recycled by 2040	80% of recyclable material is recycled by 2050	80% of recyclable material is recycled by 2030	85% of recyclable material is recycled by 2040	90% of recyclable material is recycled by 2050	90% of recyclable material is recycled by 2030	100% of recyclable material is recycled by 2040	100% of recyclable material is recycled by 2050	*NSW Waste and Sustainable Materials Strategy APC SSROC Waste Audit for components of waste EPA (2019) Disposal-based audit on Commercial and Industrial waste stream in the regulated areas of NSW APCO Waste Targets for 2025*
Waste	Waste Management	Residential and commercial and industrial waste	NSW Waste & Sustainable Materials Strategy targets include: • reduce total waste generated by 10% per person by 2030 • have an 80% average recovery rate from all waste streams by 2030 • significantly increase the use of recycled content by governments and industry • phase out problematic and unnecessary plastics by 2025 • halve the amount of organic waste sent to landfill by 2030 The Australian Packaging Covenant Organisation has established the following 2025 targets for packaging: • 100% of packaging being reusable, recyclable or compostable by 2025 • 70% of plastic packaging being recycled or composted by 2025 • 50% of average recycled content included in packaging by 2025 • The phase out of problematic and unnecessary single-use plastic packaging by 2025.	80% of e-waste recycled by 2030	80% of e-waste recycled by 2040	80% of e-waste recycled by 2050	80% of e-waste recycled by 2030	90% of e-waste recycled by 2040	100% of e-waste recycled by 2050	80% of e-waste recycled by 2030	100% of e-waste recycled by 2040	100% of e-waste recycled by 2050	*NSW Waste and Sustainable Materials Strategy APC SSROC Waste Audit for components of waste EPA (2019) Disposal-based audit on Commercial and Industrial waste stream in the regulated areas of NSW APCO Waste Targets for 2025*

Waste	Waste Management	Residential and commercial and industrial waste	The National Waste Policy outlines targets to • ban export of waste, • reduce total waste generated per person by 10% by 2030, • 80% resource recovery rate by 2030, • increase use of recycled content • phase out problem wastes • halve organic waste to landfill NSW EPA is developing a 20 year waste strategy that aligns and builds on the National Waste Policy. The related *Cleaning up our Act: Future for Waste and resource recovery in NSW* issues paper has highlighted 4 key directions: • Generate less waste • Improve collecting and sorting • Plan for future infrastructure • Create end markets	50% of organics is rescued, composted or processed for energy by 2030	50% of organics is rescued, composted or processed for energy by 2040	50% of organics is rescued, composted or processed for energy by 2050	50% of organics is rescued, composted or processed for energy by 2030	65% of organics is rescued, composted or processed for energy by 2040	75% of organics is rescued, composted or processed for energy by 2050	65% of organics is rescued, composted or processed for energy by 2030	75% of organics is rescued, composted or processed for energy by 2040	85% of organics is rescued, composted or processed for energy by 2050	*NSW Waste and Sustainable Materials Strategy APC SSROC Waste Audit for components of waste EPA (2019) Disposal-based audit on Commercial and Industrial waste stream in the regulated areas of NSW APCO Waste Targets for 2025*
Waste	Waste Management	Residential and commercial and industrial waste	NSW Waste & Sustainable Materials Strategy targets include: • reduce total waste generated by 10% per person by 2030 • have an 80% average recovery rate from all waste streams by 2030 • significantly increase the use of recycled content by governments and industry • phase out problematic and unnecessary plastics by 2025 • halve the amount of organic waste sent to landfill by 2030 The Australian Packaging Covenant Organisation has established the following 2025 targets for packaging: • 100% of packaging being reusable, recyclable or compostable by 2025 • 70% of plastic packaging being recycled or composted by 2025 • 50% of average recycled content included in packaging by 2025 • The phase out of problematic and unnecessary single-use plastic packaging by 2025.	Production of process engineered fuels resulting in 30% reduction in landfillng of residual or non recyclable waste by 2030	Production of process engineered fuels resulting in 30% reduction in landfillng of residual or non recyclable wastes by 2040	Production of process engineered fuels resulting in 30% reduction in landfillng of residual or non recyclable wastes by 2050	Production of process engineered fuels resulting in 30% reduction in landfillng of residual or non recyclable waste by 2030	Production of process engineered fuels resulting in 30% reduction in landfillng of residual or non recyclable wastes by 2040	Production of process engineered fuels resulting in 30% reduction in landfillng of residual or non recyclable wastes by 2050	Production of process engineered fuels resulting in 50% reduction in landfillng of residual or non recyclable waste by 2030	Production of process engineered fuels resulting in 50% reduction in landfillng of residual or non recyclable wastes by 2040	Production of process engineered fuels resulting in 50% reduction in landfillng of residual or non recyclable wastes by 2050	*NSW Waste and Sustainable Materials Strategy APC SSROC Waste Audit for components of waste EPA (2019) Disposal-based audit on Commercial and Industrial waste stream in the regulated areas of NSW APCO Waste Targets for 2025*
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